5 ENVIRONMENTAL IMPACTS OF ALTERNATIVES

This chapter discusses estimated potential impacts to the environment, including impacts to workers and members of the general public, under the no action alternative (Section 5.1) and the action alternatives (Section 5.2). The general assessment methodologies and major assumptions used to estimate the impacts are described in Chapter 4 and Appendix F of this EIS.

This EIS evaluates the proposed action, which is construction and operation of a conversion facility at the Paducah site for conversion of the Paducah inventory into depleted uranium oxide and other conversion products. Three alternative locations at the site are evaluated, one of which has been selected as the preferred location. This EIS also discusses impacts from preparation of cylinders for shipment at ETTP and shipment of these cylinders to the Paducah site. Shipment of ETTP cylinders to Paducah is evaluated as a reasonable option to the proposed action.

Under the no action alternative, potential environmental impacts from continued storage and maintenance of the cylinders at their current locations at the Paducah site are evaluated primarily through the year 2039, although potential long-term impacts from releases of DUF_6 and HF from future cylinder breaches are also evaluated. The potential impacts from no action at the ETTP site (i.e., continued storage and maintenance of the ETTP cylinders in their current locations) are not presented in this EIS, but in the EIS for construction and operation of a conversion facility at the Portsmouth site (DOE 2003b), the location to which the ETTP cylinder inventory is planned to be shipped.

This chapter also discusses the potential cumulative impacts of the alternatives (Section 5.3), potential mitigation actions (Section 5.4), unavoidable adverse impacts of the alternatives (Section 5.5), irreversible and irretrievable commitment of resources (Section 5.6), the relationship between short-term use of the environment and long-term productivity (Section 5.7), pollution prevention and waste minimization (Section 5.8), and D&D of the conversion facility (Section 5.9).

5.1 NO ACTION ALTERNATIVE

5.1.1 Introduction

Under the no action alternative, it is assumed that storage of DUF_6 cylinders would continue indefinitely at the Paducah site and that DOE surveillance and maintenance activities would be ongoing to ensure the continued safe storage of cylinders. Potential environmental impacts from this alternative are estimated through 2039 in this EIS, and

> **No Action Alternative**
>
> The no action alternative assumes that storage of the DUF_6 cylinders would continue for an indefinite period at the Paducah site, along with continued cylinder surveillance and maintenance. Impacts were evaluated through the year 2039, and potential long-term (beyond 2039) impacts were also evaluated.

long-term impacts (i.e., those that would occur after 2039) from cylinder breaches are also estimated. A similarly defined no action alternative is evaluated in the DUF_6 PEIS (DOE 1999a). The assessment of the no action alternative in this EIS has been updated to reflect changes that have occurred since publication of the PEIS (e.g., changes in plans for new cylinder yard construction and changes in noninvolved worker and general population numbers).

A detailed discussion of the assumptions about and impacts from continued cylinder storage activities is included in Appendix D of the PEIS; changes in impacts due to the addition of USEC-generated cylinders are discussed in Section 6.3.1 of the PEIS (DOE 1999a). Updated information on ongoing and planned cylinder maintenance activities as of June 2002 has been compiled from a database on the cylinders at the three sites and from life-cycle baseline documents for cylinder maintenance (Hightower 2002). This information was compiled prior to awarding the conversion contract to UDS and thus represents DOE's plans for long-term maintenance of cylinders without conversion, as would be the case under the no action alternative. In Section 5.1.1.1, the ongoing and planned cylinder maintenance activities assumed for the Paducah site under the no action alternative are reviewed.

Impacts associated with the following activities under the no action alternative are considered in both the PEIS and this EIS: (1) storage yard reconstruction and cylinder relocations, (2) routine and ultrasonic test inspections of cylinders and radiological monitoring and maintenance of the cylinder exteriors and valves, (3) cylinder painting, and (4) repair and removal of the contents of any cylinders that might be breached during the storage period. The frequencies for each activity assumed for the Paducah site in the PEIS are compared with planned future frequencies in Table 5.1-1. Overall, the assumptions in the PEIS result in the PEIS impacts bounding the actual impacts that could occur under current and planned future activities.

5.1.1.1 Cylinder Maintenance Activities

The PEIS assessment covered maintenance of an upper bound of 40,351 cylinders at the Paducah site. The actual inventory of cylinders actively managed by DOE is changing over time as USEC transfers cylinders to DOE under three MOAs. As of January 2004, the DOE inventory at the Paducah site consisted of 36,191 full, partially full, and heels DUF_6 cylinders (Hightower 2004). Maintenance efforts completed or underway include (1) relocation of some cylinders that either are too close to one another to allow for adequate inspections or are located in yards that require reconstruction, and (2) construction of new storage yards or reconstruction of existing storage yards to provide a stabilized concrete base and monitored drainage for the cylinder storage areas. Over the last several years, more cylinders have been relocated annually than the number assumed in the PEIS (Table 5.1-1). This relocation effort has been undertaken to achieve optimal storage conditions for all cylinders. It is expected to be completed over the next several years; consequently, after about 2008, the annual number of relocations will decrease.

TABLE 5.1-1 No Action Alternative: Comparison of Frequencies Assumed in the PEIS with Planned Frequencies for Activities at the Paducah Site

Activity	Activity-Specific Assumption	PEIS-Assumed Average Annual Activity Frequency[a]	Planned Average Annual Frequency for 2003–2007[b]
Routine cylinder inspections	30-min exposure at 1-ft (0.30-m) distance per inspection	17,200	11,500
Ultrasonic inspections	90-min exposure at about 2-ft (0.61-m) distance per inspection	440	100
Radiological monitoring and valve maintenance	1-h exposure at 1-ft (0.30-m) distance per inspection	12	860
Cylinder relocations	4-h exposure at about 8-ft (2.44-m) distance per relocation	1,020	2,800[c]
Cylinder painting	7-h exposure at 1- to 10-ft (0.30- to 3.05-m) distance per cylinder, 2 gal (8 L) of paint used, 2 gal (8 L) of LLMW generated per cylinder	4,200	1,100

[a] Source: Parks (1997), with the addition of the assumption that there would be an overall increase of 42% in activities to address the addition of USEC cylinders.

[b] Maintenance activities will be conducted in accordance with the approved cylinder management plan (Commonwealth of Kentucky and DOE, 2003). These activities are consistent with planned activities for 2003-2007 presented in this table, except the Agreed Order does not include requirements for painting.

[c] Value is the average for 2003 to 2007; after that time, few relocations are expected.

Under the DOE approved cylinder management plan (Commonwealth of Kentucky and DOE 2003), the stored cylinders are regularly inspected for evidence of damage or accelerated corrosion. Each cylinder must be inspected at least once every 4 years; however, annual inspections are required for cylinders that were previously stored in substandard conditions and those that show areas of heavy pitting or corrosion. In addition to these routine inspections, ultrasonic inspections are conducted on some of the relocated cylinders. The ultrasonic testing is a nondestructive method of measuring the thickness of cylinder walls. Radiological monitoring of the cylinder surface, especially around the valves, is also conducted for cylinders that exhibit discoloration of the valve or surrounding area during routine inspections. Leaking valves are replaced in the field. Impacts from routine inspections, ultrasonic inspections, and radiological monitoring and valve maintenance are evaluated as components of the no action alternative. In the PEIS assessment, the assumed frequencies of routine and ultrasonic inspections were overestimated by factors of about 1.5 and 4.4, respectively, in comparison with rates planned for 2003 to 2007. Radiological monitoring and valve maintenance was underestimated by a factor of about 70; however, this activity is of short duration, with little radiological exposure.

At the time the PEIS was prepared, a painting program was undertaken in an effort to arrest corrosion of the cylinders. Because the long-term painting schedule was unknown at the time, the PEIS assessment of the no action alternative assumed that as an upper bound, each cylinder would be painted every 10 years. However, after the PEIS was prepared, it was discovered that painting the cylinders increased toxicity indicators in cylinder yard runoff, such that NPDES Permit violations were occurring at the Paducah site (DOE 2000b; see Section 5.1.2.4). Also, the ongoing rate of cylinder breaches was found to be much less than the rate that had been predicted on the basis of theoretical estimates of cylinder corrosion rates, indicating that the other steps that had been taken to improve storage conditions (e.g., regular inspections and relocating cylinders out of ground contact onto concrete saddles in well-drained, concrete storage yards) were also effective in controlling corrosion. Therefore, continued cylinder maintenance plans call for a greatly reduced frequency of cylinder painting in comparison with the frequency that was assumed in the PEIS (overestimated by a factor of 3.8; Table 5.1-1). The most frequent ongoing painting activity is partial painting of the ends of skirted cylinders, which are problem areas for corrosion.

The levels of worker activity, worker exposure, and waste generation associated with cylinder painting are much higher than the levels associated with inspection, relocation, and radiological monitoring and valve maintenance activities (Table 5.1-1). Therefore, because the PEIS assumed a high frequency of cylinder painting, its estimates of impacts in several technical areas (e.g., radiological exposures of involved workers, socioeconomics, waste management) represent an upper bound on the impacts that are expected under the current and planned future cylinder maintenance programs. For this EIS, the continued storage impacts for the Paducah site estimated in the PEIS were used as the basis for the no action alternative impacts. The data have been revised as appropriate (e.g., the worker and general population numbers have been updated).

With respect to impacts on air quality, yard reconstruction results in criteria pollutant emissions from vehicle exhaust and fugitive dust generation. The quantity of emissions is generally proportional to the disturbed land area. The PEIS modeled the maximum annual impacts from reconstruction of four yards at the Paducah site. The largest yard (C-745-L) was estimated to be about 310,000 ft^2 (28,800 m^2). Since publication of the PEIS, reconstruction of four yards has been completed. If no conversion facility was constructed, the cylinder management plan for the site calls for the reconstruction of C-745-N and C-745-P (N-yard and P-yard) concurrently over about 6 months in 2006, and the reconstruction of C-745-F (F-yard) over 7 months in the following year. The combined area of N-yard and P-yard is about 164,000 ft^2 (15,200 m^2); the area of F-yard is about 250,000 ft^2 (23,200 m^2).

This EIS includes the reconstruction of N-yard, P-yard, and F-yard in the impacts assessment. It is assumed that the PEIS air quality impact estimates are representative and bounding for the estimate of impacts of new yard construction under the no action alternative for the following reasons: (1) both planned yard reconstruction projects are smaller than the largest project modeled for the PEIS, (2) the PEIS projects and the planned reconstruction projects are located in close proximity to one another on the site; and (3) air quality impacts are measured on an annual basis (they are not cumulative). Also, because all of the recently constructed or to-be-constructed yards are in previously disturbed areas, impacts to cultural resources and ecological resources would be similar to impacts discussed in the PEIS. The specific impacts of yard reconstruction under the no action alternative for each technical area are discussed in Section 5.1.2.

5.1.1.2 Assumptions and Methods Used to Assess Impacts Associated with Cylinder Breaches

To estimate the impacts from continued cylinder storage, it is necessary to predict the number of cylinder breaches that might occur in the future. A cylinder is considered breached if it has a hole of any size at some location on the cylinder wall. At the time the PEIS was published (1999), 8 breached cylinders had been identified at the three storage sites; 1 of these was at the Paducah site. Investigation of these breaches indicated that 6 of the 8 were initiated by mechanical damage during stacking; the damage was not noticed immediately, and subsequent corrosion occurred at the point of damage. It was concluded that the other 2 cylinder breaches (both at the ETTP site) had been caused by external corrosion due to prolonged ground contact. The breached cylinders were patched, pending decisions on long-term management. However, these breached cylinders may eventually require emptying through cold-feeding (a lengthy process of heating a cylinder to a temperature just below the UF_6 liquefaction point so that the UF_6 changes directly from solid to gaseous form).

From 1998 through 2002, 2 additional breaches were discovered at the Paducah site (Hightower 2002).[1] These breaches were the result of missing cylinder plugs. The breach rate over this time period was 0.4 per year (2 breaches in 5 years). The breached cylinders were repaired.

For assessment purposes in this EIS, 2 cylinder breach cases were evaluated. The first is a case in which it was assumed that the planned cylinder maintenance and painting program would maintain the cylinders in a protected condition and control further corrosion. It was assumed that after the initial painting, some cylinder breaches would result from handling damage. For this case, the total number of future breaches estimated to occur through 2039 at the Paducah site is 36 (i.e., about 1 per year). In the second case, it was assumed that external corrosion would not be halted by improved storage conditions, cylinder maintenance, and/or painting. This case was considered in order to account for uncertainties in both the effectiveness of painting in controlling cylinder corrosion and uncertainties in the future painting schedule. For this scenario,

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[1] A breach that occurred at the ETTP site in 1998 was discussed in Section B.2 of the PEIS (DOE 1999a). A total of 11 breaches have been identified at the Portsmouth, ETTP, and Paducah sites (Hightower 2002).

the number of breaches estimated through 2039 was 444 for the Paducah site (i.e., 11 per year). This breach estimate is based on the historical corrosion rate determined when the cylinders were stored under poor conditions (i.e., cylinders were stacked too close together, were stacked on wooden chocks, or came in contact with the ground). Details concerning development of the breach estimates are provided in Appendix B of the PEIS (DOE 1999a).

The impacts to human health and safety, surface water, groundwater, soil, air quality, and ecology from uranium and HF releases from breached cylinders are assessed in this EIS. For all hypothetical cylinder breaches, it was assumed that the breach would go undetected for 4 years, which is the period between planned inspections for most of the cylinders. In practice, cylinders that show evidence of damage or heavy external corrosion are inspected annually, so it is very unlikely that a breach would go undetected for a 4-year period. For each hypothetical cylinder breach, it was further assumed that 1 lb (0.45 kg) of uranium (as UO_2F_2) and 4.4 lb (2 kg) of HF would be released from the cylinder annually for a period of 4 years. The cylinder management plan (Commonwealth of Kentucky and DOE 2003) outlines procedures to be taken in the event of a cylinder breach and/or release of DUF_6 from one or more cylinders.

Radiological exposures of involved workers could result from patching breached cylinders or emptying the contents of breached cylinders into new cylinders. The assumptions used to estimate impacts to involved workers were that (1) it would require 32 hours of exposure at a distance of 1 ft (0.30 m) to temporarily patch each cylinder, and (2) it would require an additional 961 hours of exposure at a distance of about 10 ft (3.05 m) to empty a cylinder by cold-feeding.

Groundwater impacts were assessed by first estimating the amount of uranium that could be transported from the yards in surface runoff, and then by estimating migration through the soil to groundwater. HF air concentrations were also modeled.

The lower breach estimate for breaches due to cylinder handling is likely to be a reasonable upper-bound estimate of a breach rate that would occur during long-term continued storage under a no action alternative (e.g., the actual rate over the last 5 years was 0.4 breach per year; the model estimates 1 breach per year). Because storage conditions have improved dramatically as a result of cylinder yard upgrades and restacking activities over the last several years, the breach estimate based on the historical corrosion rate (i.e., 11 breaches per year) is likely a worst-case estimate of what could occur if DOE discontinued active management of the cylinders. In this assessment, the worst-case scenario is used to estimate the earliest time when continued cylinder storage could begin to raise regulatory concerns, such as when drinking water standards would be exceeded in groundwater or when air quality criteria would be exceeded (see Sections 5.1.2.3 and 5.1.2.4.2).

5.1.2 Impacts of No Action at the Paducah Site

The impacts described in this section are similar to those presented in Section 3.5.2 of the data compilation report for the Paducah site (Hartmann et al. 1999); however, they have been adjusted to account for changes in noninvolved worker and general population numbers since the time of that assessment.

5.1.2.1 Human Health and Safety

Under the no action alternative, impacts to human health and safety could result from cylinder maintenance operations during both routine conditions and accidents. In general, the impacts during normal operations at the Paducah site would be limited to workers directly involved in handling cylinders. Under accident conditions, the health and safety of both workers and members of the general public around the site could be affected.

5.1.2.1.1 Normal Facility Operations

Workers. Cylinders containing DUF_6 emit low levels of gamma and neutron radiation. Involved workers would be exposed to this radiation when near cylinders, such as during routine cylinder monitoring and maintenance activities, cylinder yard reconstruction, cylinder relocation and painting, and cylinder patching or repair. It is estimated that an average of about 43 cylinder yard maintenance workers would be required at the Paducah site. These workers would be trained to work in a radiation environment, they would use protective equipment as necessary, and their radiation exposure levels would be measured and monitored by safety personnel at the sites. Radiation exposure of workers is required by law to be maintained ALARA and not to exceed 5,000 mrem/yr (10 CFR Part 835).

Involved workers reconstructing existing cylinder yards would incur external radiation from the DUF_6 cylinders stored at nearby yards. According to radiation survey data for two empty cylinder yards, C-745-K and C-745-K1, in February 2002, the average dose rate within the empty yards was about 0.2 mrem/h (Hicks 2002b). On the basis of the assumptions that the reconstruction projects would last for a maximum of 7 months and the workers would spend, at most, 1,170 hours per reconstruction project working in the vicinity of the storage yards, it is estimated that the maximum dose a worker would receive would be about 230 mrem per reconstruction project. If the same workers conducted both planned reconstruction projects, the maximum total dose over 2 years would be 460 mrem. This is well within the standard required by law of 5,000 mrem/yr for radiation workers (10 CFR Part 835).

The radiation exposure of involved workers (cylinder yard workers) in future years through 2039 is estimated to be well within public health standards (10 CFR Part 835). If the same 43 workers conducted all cylinder management activities, the average annual dose to individual involved workers would be about 740 mrem/yr. The estimated future doses do not account for standard ALARA practices that would be used to keep the actual doses as far below the limit as practicable. Thus, the future doses to workers are expected to be less than those estimated because of the conservatism in the assumptions and models used to generate the estimates. In fact, in 2001, the measured doses to cylinder yard workers ranged from about 170 to 427 mrem/yr, with an average of 254 mrem/yr (Hicks 2002a). The radiation exposure of the noninvolved workers was estimated to be less than 0.15 mrem/yr.

It is estimated that the total collective dose to all involved cylinder maintenance workers at the Paducah site from 1999 through 2039 would be about 1,300 person-rem. (The collective dose to noninvolved workers would be negligible [i.e., less than 0.01%], compared with the collective dose to involved workers.) This dose would be distributed among all of the workers involved with cylinder activities over the no action period. Although about 43 workers would be required each year, the actual number of different individuals involved over the period would probably be much greater than 43 because workers could be rotated to different jobs and could change jobs. It is estimated that this level of exposure could potentially result in less than 1 LCF (i.e., 0.5 LCF) among all the workers exposed, in addition to the cancer cases that would result from all other causes not related to the no action alternative activities.

As discussed in Chapter 1 and Appendix B of this EIS, some portion of the DUF_6 inventory contains TRU and Tc contamination. The contribution of these contaminants to potential external radiation exposures under normal operations was evaluated on the basis of the bounding concentrations presented in Appendix B. The dose from these contaminants was estimated and compared with the dose from the depleted uranium and uranium decay products in the DUF_6. It is estimated that under typical cylinder maintenance conditions, the TRU and Tc contaminants would make only a very small contribution to the radiation doses, amounting to approximately 0.2% of the dose from the depleted uranium and its decay products.

No impacts to involved workers are expected from exposure to chemicals during normal cylinder maintenance operations. Exposures to chemicals during cylinder painting operations would be monitored to ensure that airborne chemical concentrations were within applicable health standards protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, those workers would be provided with appropriate protective equipment as necessary.

Chemical exposures to noninvolved workers could result from airborne emissions of UO_2F_2 and HF that could be dispersed from hypothetical cylinder breaches into the atmosphere and to ground surfaces. It is estimated that the potential chemical exposures of noninvolved workers from any airborne releases during normal operations would be below levels expected to cause adverse effects. (The hazard index was estimated to be less than 0.1 for noninvolved workers.)

General Public. Potential health impacts to members of the general public could occur if material released from breached cylinders entered the environment and was transported from the site through the air, surface water, or groundwater. Off-site releases of uranium and HF from breached cylinders are possible. However, it is estimated that the off-site concentrations of these contaminants in the future would be much less than levels expected to cause adverse effects. Potential exposures of members of the general public would be well within public health standards. No adverse effects (LCFs or chemical effects) are expected to occur among members of the general public residing within 50 mi (80 km) of the Paducah site as a result of DUF_6 continued storage activities.

If all the uranium and HF assumed to be released from hypothetical breached cylinders through 2039 were dispersed from the site through the air, the total collective radiation dose to the general public (all persons within 50 mi [80 km]) would be less than 0.3 person-rem. This level of exposure would most likely result in zero cancer fatalities among members of the general public. For comparison, the total collective radiation dose from natural background and medical sources to the same population group in 40 years would be about 7.4×10^6 person-rem. The maximum radiation dose to an individual near the site would be less than 0.1 mrem/yr, well within health standards. Radiation doses to the general public are required by health regulations to be maintained at below 10 mrem/yr from airborne sources (40 CFR Part 61) and below a total of 100 mrem/yr from all sources combined (DOE 1990). If an individual received the maximum estimated dose every year, the total dose would be less than 4 mrem, resulting in an additional chance of dying from a latent cancer of about 1 in 500,000. No noncancer health effects from exposure to airborne uranium and HF releases are expected; the estimated hazard index for an MEI is less than 0.1. This means that the total exposure would be at least 10 times less than exposure levels that might cause adverse effects.

The material released from breached cylinders could also have the potential to be transported from the site in water, either in surface water runoff or by infiltrating the soil and contaminating groundwater. Members of the general public could be exposed if they used this contaminated surface water or groundwater as a source of drinking water. The results of the surface water and groundwater analyses indicate that the maximum estimated uranium concentrations in surface water accessible to the general public and in groundwater beneath the site would be less than 20 μg/L (the proposed EPA drinking water standard has now been finalized at 30 μg/L and became effective in December 2003 [EPA 2003b]). Drinking water standards, meant to apply to water "at the tap" of the user, are set at levels protective of human health. In this assessment, 20 μg/L was used as a guideline level for the surface water and groundwater analyses.

If a member of the general public used contaminated water at the maximum concentrations estimated, adverse effects would be unlikely. Even if a member of the general public used contaminated surface water or groundwater as his or her primary water source, the maximum radiation dose in the future would be less than 0.5 mrem/yr. The corresponding increased risk to this individual of dying from a latent cancer would be less than 1 in 1 million per year. Noncancer health effects from exposure to possible water contamination are not expected; the estimated maximum hazard index for an individual assumed to use the groundwater is less than 0.05. This result means that the total exposure would be 20 times less than the exposure that might cause adverse effects.

If no credit was taken for the reduction in cylinder corrosion rates as a result of cylinder maintenance and painting activities, the groundwater analysis indicates that the uranium concentration in groundwater could exceed 20 μg/L at some time in the future (see Section 5.1.2.4). This scenario is highly unlikely because ongoing cylinder inspection and maintenance would prevent significant releases from occurring, especially for as many cylinders as are assumed here (i.e., 444 breaches). Nonetheless, if contamination of groundwater used as drinking water occurred in the future, treating the water or supplying an alternative source of water might be required to ensure the safety of those potentially using the water.

5.1.2.1.2 Facility Accidents

Physical Hazards (On-the-Job Injuries and Fatalities). Accidents occur in all work environments. In 2000, about 5,200 people in the United States were killed in accidents while at work, and approximately 3.9 million disabling work-related injuries were reported (National Safety Council 2002). Although all work activities would be conducted in as safe a manner as possible, there is a chance that workers could be accidentally killed or injured under the no action alternative, unrelated to any radiation or chemical exposures.

The numbers of accidental worker injuries and fatalities that might occur through 2039 were estimated on the basis of the number of workers required and the historical accident fatality and injury rates in similar types of industries. It is estimated that a total of less than 1 accidental fatality (i.e., about 0.07, or about 7 chances in 100 of a single fatality) might occur at the Paducah site over the no action period evaluated. A total of about 82 accidental injuries (defined as injuries resulting in lost workdays) are estimated for cylinder maintenance activities. Two accidental injuries would be associated with cylinder yard reconstruction. The rates are not unique to the activities required for the no action alternative but are typical of any industrial project of similar size and scope.

Accidents Involving Radiation or Chemical Releases. Under the no action alternative, accidents could release radiation and chemicals from cylinders. Several types of accidents were evaluated. Included were those initiated by operational events, such as equipment or operator failure; external hazards, such as aircraft crashes; and natural phenomena, such as earthquakes. The assessment considered accidents ranging from those that would be reasonably likely to occur (one or more times in 100 years on average) to those that would be extremely rare (estimated to occur less than once in 1 million years on average).

The accidents of most concern at the Paducah site under the no action alternative would be accidents that could cause a release of UF_6 from cylinders. In a given accident, the amount potentially released would depend on the severity of the accident and the number of cylinders involved. Following a release, the UF_6 could combine with moisture in the air, forming gaseous HF and UO_2F_2, a soluble solid in the form of small particles. The depleted uranium and HF could be dispersed downwind, potentially exposing workers and members of the general public living near the site to radiation and chemical effects. The workers considered in the accident assessment were those noninvolved workers not immediately in the vicinity of the accident; fatalities and injuries among involved workers would be possible if accidents were severe.

The estimated consequences of cylinder accidents are summarized in Table 5.1-2 for chemical effects and Table 5.1-3 for radiation effects. The impacts are the maximums estimated for the Paducah site. The impacts are presented separately for likely accidents and for rare, low-probability accidents estimated to result in the largest potential impacts. Although other accidents were evaluated (see Hartmann 1999, Section 3.2.2), the estimated consequences of those other accidents would be less than the consequences of the accidents summarized in these tables. The estimated consequences are conservative in that they were based on the assumption

TABLE 5.1-2 No Action Alternative: Estimated Consequences of Chemical Exposures for Cylinder Accidents at the Paducah Site[a]

Receptor[b]	Accident Scenario	Accident Frequency Category[c]	Potential Effect[d]	Consequence[e] (no. of persons affected)
Likely Accidents				
General public	Corroded cylinder spill, dry conditions	L	Adverse effects	0
	Corroded cylinder spill, dry conditions	L	Irreversible adverse effects	0
	Corroded cylinder spill, dry conditions	L	Fatalities	0
Noninvolved workers	Corroded cylinder spill, dry conditions	L	Adverse effects	0–10
	Corroded cylinder spill, dry conditions	L	Irreversible adverse effects	0–1
	Corroded cylinder spill, dry conditions	L	Fatalities	0
Low Frequency-High Consequence Accidents				
General public	Rupture of cylinders – fire	EU	Adverse effects	3–2,000
	Corroded cylinder spill, wet conditions – water pool	EU	Irreversible adverse effects	0–1
	Corroded cylinder spill, wet conditions – water pool	EU	Fatalities	0
Noninvolved workers	Rupture of cylinders – fire	EU	Adverse effects	4–910
	Corroded cylinder spill, wet conditions – water pool	EU	Irreversible adverse effects	1–300
	Corroded cylinder spill, wet conditions – water pool	EU	Fatalities	0–3

Footnotes on next page.

TABLE 5.1-2 (Cont.)

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[a] The accidents listed are those estimated to result in the greatest impacts among all the accidents considered (except for certain accidents with security concerns). The site-specific impacts for a range of accidents at the Paducah site are given in Hartmann et al. (1999).

[b] Noninvolved workers are persons who work at the site but who are not involved in handling materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

[c] Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} to 10^{-6}/yr).

[d] Potential adverse effects include exposures that could result in mild and transient injury, such as respiratory irritation. Potential irreversible adverse effects include exposures that could result in permanent injury (e.g., impaired organ function) or death. The majority of the adverse effects would be mild and temporary in nature. It is estimated that less than 1% of the predicted potential irreversible adverse effects would result in fatalities (see text).

[e] The consequence is expressed as the number of individuals with a predicted exposure level sufficient to cause the corresponding health endpoint. The range of estimated consequences reflects different atmospheric conditions at the time of an accident assumed to occur at the cylinder yard closest to the site boundary. In general, maximum risks would occur under atmospheric conditions of F stability with a 1-m/s (2-mph) wind speed; minimum risks would occur under D stability with a 4-m/s (9-mph) wind speed. For both conditions, it was assumed that the wind would be blowing in the direction of the highest density of worker or public populations.

that the wind would be blowing in the direction of the greatest number of people at the time of the accident. In addition, the effects of protective measures, such as evacuation, were not considered.

An exception to the discussion above would be a certain class of accidents that DOE investigated; however, because of security concerns, information about such accidents is not available for public review but is presented in a classified appendix to this EIS. All classified information will be presented to state and local officials, as appropriate.

Chemical Effects. The potential likely accident (defined as an accident estimated to occur one or more times in 100 years) that would cause the largest chemical health effects is the failure of a corroded cylinder that would spill part of its contents under dry weather conditions. Such an accident could occur, for example, during cylinder handling activities. It is estimated that about 24 lb (11 kg) of DUF_6 could be released in such an accident. The potential consequences from this type of accident would be limited to on-site workers. The off-site concentrations of HF and uranium were calculated to be less than the levels that would cause adverse effects from exposure to these chemicals, so that zero adverse effects would occur among members of the general public. It is estimated that if this accident did occur, up to 10 noninvolved workers might experience potential adverse effects from exposure to HF and

TABLE 5.1-3 No Action Alternative: Estimated Consequences from Radiation Exposures for Cylinder Accidents at the Paducah Site[a]

			MEI		Population	
Receptor[b]	Accident Scenario	Accident Frequency Category[c]	Dose (rem)	Lifetime Risk of LCF	Dose (person-rem)	Number of LCFs
Likely Accidents						
General public	Corroded cylinder spill, dry conditions	L	0.0023	1×10^{-6}	0.27	0.0001
Noninvolved workers	Corroded cylinder spill, dry conditions	L	0.077	3×10^{-5}	1.4	0.0006
Low Frequency-High Consequence Accidents						
General public	Rupture of cylinders – fire	EU	0.015	7×10^{-6}	29	0.01
Noninvolved workers	Rupture of cylinders – fire	EU	0.02	8×10^{-6}	15	0.006

a The accidents listed are those estimated to have the greatest impacts among all the accidents considered (except for certain accidents with security concerns). The site-specific impacts for a range of accidents at the Paducah site are given in Hartmann et al. (1999). The estimated consequences were based on the assumption that at the time of the accident, the wind would be blowing in the direction of the highest density of workers or public population and that weather conditions would limit dispersion.

b Noninvolved workers are persons who work at the site but who are not involved in handling materials. Depending on the circumstances of the accident, injuries and fatalities among involved workers are possible for all accidents.

c Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} to 10^{-6}/yr).

uranium (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). It is estimated that one noninvolved worker might experience potential irreversible adverse effects (such as lung or kidney damage). The number of fatalities following an HF or uranium exposure is expected to be somewhat less than 1% of the number of potential irreversible adverse effects (Policastro et al. 1997). Therefore, no fatalities are expected.

For assessment purposes, the estimated frequency of a corroded cylinder spill accident is assumed to be about once in 10 years. Therefore, over the no action period, about four such accidents are expected. The accident risk (defined as consequence × probability) would be about 40 workers with potential adverse effects, and 4 workers with potential irreversible adverse effects. The number of workers actually experiencing these effects would probably be considerably less, depending on the actual circumstances of the accidents and the individual chemical sensitivity of the workers. In previous accidental exposure incidents involving liquid

UF_6 in gaseous diffusion plants, a few workers were exposed to amounts of uranium estimated to be approximately three times the guidelines used for assessing irreversible adverse effects in this EIS, and none actually experienced irreversible adverse effects (McGuire 1991).

Accidents that are less likely to occur could have higher consequences. The potential cylinder accident at the site estimated to result in the greatest total number of adverse chemical effects would be an accident involving several cylinders in a fire. It is estimated that about 24,000 lb (11,000 kg) of DUF_6 could be released in such an accident. If this accident occurred, it is estimated that up to 2,000 members of the general public and 910 noninvolved workers might experience adverse effects from HF and uranium exposure (mostly mild and transient effects, such as respiratory irritation or temporary decrease in kidney function). This accident is considered extremely unlikely, it is estimated to occur between once in 10,000 years and once in 1 million years. If the frequency is assumed to be once in 100,000 years, the accident risk over the no action period would be less than 1 adverse effect for both workers and members of the general public.

The potential cylinder accident estimated to result in the largest total number of irreversible adverse effects is a corroded cylinder spill under wet conditions, for which the UF_6 is assumed to be released into a pool of standing water. This accident is also considered extremely unlikely; that is, it is expected to occur between once in 10,000 years and once in 1 million years. It is estimated that if this accident did occur, about 1 member of the general public and 300 noninvolved workers might experience irreversible adverse effects (such as lung damage) from HF and uranium exposure. The number of fatalities would be somewhat less than 1% of the estimated number of potential irreversible adverse effects (Policastro et al. 1997). Thus, no fatalities are expected among the general public, although three fatalities could occur among noninvolved workers (1% of 300). If the frequency of this accident is assumed to be once in 100,000 years, the accident risk through 2039 would be less than 1 (0.1) irreversible adverse health effect among workers and the general public combined.

Radiation Effects. Potential cylinder accidents could release uranium, which is radioactive in addition to being chemically toxic. The potential radiation exposures of members of the general public and noninvolved workers were estimated for the same cylinder accidents as those for which chemical effects were estimated (Table 5.1-3). For all cylinder accidents considered, it is estimated that the radiation doses from released uranium would be considerably below levels likely to cause radiation-induced effects among noninvolved workers and the general public and below the 25-rem total effective dose equivalent established by DOE as a guideline for assessing the adequacy of protection of public health and safety from potential accidents (DOE 2000c).

For the corroded cylinder spill accident (dry conditions), it is estimated that the radiation dose to a maximally exposed member of the general public would be less than 3 mrem (lifetime dose), resulting in an increased risk of death from cancer of about 1 in 1 million. The total population dose to the general public within 50 mi (80 km) would be less than 1 person-rem, most likely resulting in zero LCFs. Among noninvolved workers, the dose to an MEI would be 77 mrem, resulting in an increased risk of death from cancer of about 1 in 30,000. The total dose to all noninvolved workers would be about 1.4 person-rem. It is estimated that this dose to workers would result in no LCFs. The risk (consequence × probability) of additional LCFs among members of the general public and workers combined would be much less than 1 through 2039.

The cylinder accident estimated to result in the largest potential radiation doses would be the accident involving several cylinders in a fire. For this accident, it is estimated that the radiation dose to a maximally exposed member of the general public would be about 15 mrem, resulting in an increased risk of death from cancer of about 1 in 150,000. The total population dose to the general public within 50 mi (80 km) would be 29 person-rem, most likely resulting in no LCFs. Among noninvolved workers, the dose to an MEI would be about 20 mrem, resulting in an increased risk of death from cancer of about 1 in 100,000. The total dose to all noninvolved workers would be about 15 person-rem. This dose to workers would result in no LCFs. The risk (consequence × probability) of additional LCFs among members of the general public and workers combined would be much less than 1 through 2039.

5.1.2.2 Transportation

Continued cylinder storage under the no action alternative would have the potential to generate small amounts of LLW and LLMW during cylinder monitoring and maintenance activities. This material could require transportation to a treatment or disposal facility. Shipments would be made in accordance with all DOE and DOT regulations and guidelines. It is estimated that less than one waste shipment would be required each year. Because of the small number of shipments and the low concentrations of contaminants expected, the potential environmental impacts from these shipments would be negligible.

5.1.2.3 Air Quality and Noise

The assessment of potential impacts to air quality under the no action alternative included a consideration of air pollutant emissions from continued cylinder storage activities, including emissions from reconstruction of cylinder yards (engine exhaust and particulate matter emissions [i.e., dust]), emissions from operations (cylinder painting and vehicle emissions), and HF emissions from breached cylinders. An atmospheric dispersion model was used to estimate the concentrations of criteria pollutants at the site boundaries: SO_2, NO_2, CO_2, O_3, PM (PM_{10} and $PM_{2.5}$), and Pb. The site boundary concentrations were compared with existing air quality standards given in Chapter 3. For the no action alternative, it is estimated that concentrations of criteria pollutants and HF would be within applicable standards. However, because potential PM_{10} concentrations during yard reconstruction activities would be very close to the standards, mitigation measures to reduce these emissions might have to be implemented during construction.

The highest levels of criteria pollutants generally would be generated by yard reconstruction activities. Except for PM, the air concentrations of all criteria pollutants resulting from no action alternative activities would be less than or equal to 0.02% of the respective standards. PM emissions from construction could result in maximum 24-hour average PM_{10} concentrations just below the standards (about 90% of the 24-hour standard value of 150 μg/m^3), although the estimated annual average concentrations would be lower (about 33% of the standard value of 50 μg/m^3). During yard reconstruction activities, mitigative measures, such as spraying the soil with water and covering excavated soil, would be taken to reduce the generation of particulate matter. Such measures are commonly employed during construction but were not accounted for in the modeling. Planned construction activities at the Paducah site for the no action alternative are the reconstruction of cylinder yards C-745-N and C-745-P (combined area of 164,000 ft^2 [15,200 m^2] in 2006, and of C-745-F, with an area of about 250,000 ft^2 (23,000 m^2), in 2007.

Operations would emit much lower concentrations of criteria pollutants than would reconstruction. Criteria pollutant emissions would all be lower than 0.3% of standards. Painting of cylinders could generate hydrocarbon emissions. Although no explicit air quality standard has been set for hydrocarbon emissions, these emissions are associated with ozone formation. Standards have been set for ozone. For the Paducah site, hydrocarbon emissions from painting activities were estimated to be less than 1.2% of the hydrocarbon emissions from the entire surrounding county. Because ozone formation is a regional issue affected by emissions for an entire area, this small additional contribution to the county total would be unlikely to substantially alter the ozone levels of the county. In addition, the actual frequency of cylinder painting is expected to be greatly reduced from the level assumed.

When credit is taken for reduced corrosion from better maintenance and painting, the estimated maximum 24-hour and annual average site boundary HF concentrations from hypothetical cylinder breaches occurring under the no action alternative at the Paducah site are 0.08 μg/m^3 and 0.0093 μg/m^3, respectively. The Kentucky HF standards are 2.9 μg/m^3 (secondary standard for 24-hour maximum average) and 400 μg/m^3 (primary annual average standard). The annual average HF concentration for the Paducah site is estimated to be less than 0.002% of the standard; the maximum 24-hour average is estimated to be 2.8% of the standard.

Calculations indicate that if no credit was taken for the reduction in corrosion as a result of painting and continued maintenance and if storage continued at the Paducah site indefinitely, breaches occurring at the site by around 2039 could result in maximum 24-hour average HF concentrations at the site boundary of 2 μg/m^3, about 69% of the state secondary standard. Because of the ongoing maintenance program, it is not expected that a breach rate this high would occur at the Paducah site.

At Paducah, planned reconstruction of cylinder yards over several months could result in increased noise levels. At the nearest residence, located about 1.9 km (1.2 mi) from the cylinder yards, estimated noise levels would be well below the EPA guideline of 55 dB(A) as DNL for residential zones (EPA 1974). Adverse noise impacts from cylinder yard reconstruction activities are not expected.

Continued storage operations could result in somewhat increased noise levels at the site as a result of activities such as painting or repairing any infrequent cylinder breaches. However, it is expected that the noise levels at off-site residences would not increase noticeably. Noise impacts are expected to be negligible under the no action alternative.

5.1.2.4 Water and Soil

Under the no action alternative, continued storage of the cylinders at the Paducah site would have the potential to affect surface water, groundwater, and soil. Important elements in assessing potential impacts on surface water include changes in runoff, floodplain encroachment, and water quality. Groundwater impacts were assessed in terms of changes in recharge to the underlying aquifers, depth to groundwater, direction of groundwater flow, and groundwater quality. Potential soil impacts considered were changes in topography, permeability, erosion potential, and soil quality.

Under the no action alternative, the planned cylinder yard reconstruction activity would occur in previously developed areas. Water use and wastewater discharge would be limited. Therefore, the assessment area in which potentially important impacts might occur was determined to be quality of surface water, groundwater, and soil. All the other potential impacts would depend on changes in permeable land areas at the sites as a result of construction activities or would depend on water use, effluent volumes, and effluent composition and concentrations.

A contaminant of concern for evaluating surface water, groundwater, and soil quality is uranium. Surface water and groundwater concentrations of contaminants are generally evaluated through comparison with EPA MCLs, as given in Safe Drinking Water Act regulations (40 CFR Part 141), although these limits are only directly applicable “at the tap” of the water user. The water concentration value for uranium used for comparison in this EIS is 20 μg/L (i.e., the proposed MCL for uranium has now been finalized at 30 μg/L and became effective in December 2003 [EPA 2003b]). The 20-μg/L level is used as a guideline for evaluating surface water and groundwater concentrations of uranium in this EIS, even though it is not directly applicable as a standard. There is also no standard available for limiting concentrations of uranium in soil. A health-based value of 230 μg/g (EPA 1995), applicable for residential settings, is used as a guideline for comparison.

The nearest surface water to the Paducah site is Little Bayou Creek, which is a tributary to the Ohio River. The Ohio River is used as a drinking water source. Because of very large dilution effects, even high levels of contaminants in Little Bayou Creek would not be expected to cause levels exceeding guidelines at the drinking water intakes of the Ohio River.

Reconstruction of storage yards is estimated to require approximately 0.5 million gal (2 million L) of water for each of the two projects. Maximum water use for continued maintenance activities would be 230,000 gal/yr (870,000 L/yr).

5.1.2.4.1 Surface Water. Potential impacts on the nearest receiving water at the site (i.e., Little Bayou Creek) were estimated for uranium released from hypothetical cylinder breaches occurring through 2039. The estimated maximum concentration of uranium in Little Bayou Creek would be 0.3 μg/L, considerably below the 20-μg/L level used for comparison.

At the Paducah site, KPDES Outfall 017 receives runoff from the cylinder storage yards and from the cylinder painting facility area. Cylinder painting operations were ongoing in 1998; the entire bodies of 1,200 cylinders were painted in that year (Hightower 2002). Toward the end of 1998, results from two separate acute toxicity tests of water fleas (*Ceriodaphnia dubia*) conducted at KPDES Outfall 017 exceeded specified limits; the runoff was not toxic to flathead minnows (*Pimephales promelas*). Evaluations seemed to indicate that zinc in runoff from recent painting activities was the leading contributor to the toxicity of the runoff (DOE 2000b). No cylinder painting was conducted at the site in 1999, and effluent from KPDES Outfall 017 did not exceed toxicity limits in that year (DOE 2001b). In 2000 and 2001, acute toxicity tests at the outfall again exceeded toxicity limits, although no cylinder painting was occurring (DOE 2002e). It is possible that cylinder painting activities at the Paducah site might result in KPDES Permit violations in the future. Mitigating actions, such as treating runoff, could be implemented if this problem arose.

5.1.2.4.2 Groundwater. Groundwater in the vicinity of the Paducah site is used for domestic and industrial supplies. Existing groundwater quality at the site is discussed in Section 3.1-5. The Paducah site provides a municipal water supply to residents whose wells are within an area of groundwater contaminated with TCE and Tc-99. Activities associated with the no action alternative would not affect migration of existing groundwater contamination or further impact off-site water supplies.

Potential impacts on groundwater quality from hypothetical releases of uranium from breached cylinders were also assessed. The maximum future concentration of uranium in groundwater directly below the Paducah site is estimated to be 6 μg/L, which is considerably below the 20-μg/L level used for comparison. It is estimated that if the rate of uranium migration was rapid, this concentration would occur sometime after 2070. A lower concentration would occur if uranium migration through the soil was slower than assumed for this analysis.

Calculations indicate that if no credit was taken for the reduction in corrosion as a result of cylinder painting and maintenance and if storage continued at the Paducah site indefinitely, uranium releases from future cylinder breaches occurring before about 2020 could result in a sufficient amount of uranium in the soil column to increase the groundwater concentration of uranium to 20 μg/L in the future. The groundwater concentration would not actually reach 20 μg/L at the site until about 2100 or later. However, because of the ongoing cylinder maintenance program, it is expected that breaches occurring prior to 2039 would not be sufficient to increase the groundwater concentration of uranium to 20 μg/L at the site.

5.1.2.4.3 Soil. Potential impacts on soil that could receive contaminated rainwater runoff from the cylinder storage yards were estimated. The source is assumed to be uranium released from hypothetical breached cylinders. It is assumed that any releases from future cylinder painting activities would be controlled or treated to avoid soil contamination. The estimated maximum soil concentration is 1 μg/g for the Paducah site, considerably below the 230-μg/g guideline used for comparison.

5.1.2.5 Socioeconomics

The potential socioeconomic impacts of reconstruction and operational activities under the no action alternative at the Paducah site would be low. Reconstruction activities would create short-term employment (30 direct jobs, 110 total jobs over each of 2 construction years), and operational activities at the site would create 90 direct jobs and 130 total jobs per year. Direct and total income from reconstruction in the peak year would be $1.6 million and $3.2 million, respectively. During operations, direct and total income would be $3.0 million/yr and $3.8 million/yr, respectively.

The employment created in the ROI for the Paducah site would represent a change of less than 0.1 of a percentage point in the projected average annual growth in employment over the period 2004 to 2039. With no in-migration into the ROI expected during continued storage, no impacts on housing, local public finances, or local service employment are expected.

5.1.2.6 Ecology

The no action alternative would have a negligible impact on ecological resources in the area of the Paducah site. Very limited construction activity is planned, and all activities that are expected would occur in previously developed areas. Thus, impacts on wetlands and federal- and state-protected species from construction are expected to be negligible.

The assessment results indicate that impacts to ecological resources from continued storage, including hypothetical cylinder breaches, would be negligible. Analysis of potential impacts was based on exposure of biota to airborne contaminants or contaminants released to soil, groundwater, or surface water (e.g., from painting activities or from breached cylinders). Predicted concentrations of contaminants in environmental media were compared with benchmark values for toxic and radiological effects (see Appendix F). At the Paducah site, air, soil, and surface water concentrations would be below levels harmful to biota. However, as discussed in Section 5.1.2.4.1, cylinder painting activities may potentially result in future reductions in surface water quality, and they may consequently cause impacts to aquatic biota downstream at KPDES Outfall 017. Although groundwater uranium concentrations (6 to 20 μg/L) would be below the lowest effects level (150 μg/L) and below radiological benchmark levels (4.55×10^3 pCi/L), they would exceed the ecological screening value for surface water (2.6 μg/L). However, contaminants in groundwater discharging to a surface water body, such as a local stream, would be quickly diluted to negligible concentrations.

5.1.2.7 Waste Management

Under the no action alternative, construction and operations at the Paducah site would generate relatively small amounts of LLW and LLMW (including PCB-containing wastes). The volume of LLW generated by continued storage activities would represent less than 1% of the annual generation at the site from all activities. The maximum annual amount of LLMW generation from stripping/painting operations at the Paducah site would be about 30 yd^3/yr (23 m^3/yr), which is about 0.3% of the site's total annual LLMW load. Thus, the overall impact on waste management operations from the no action alternative would be negligible.

5.1.2.8 Resource Requirements

Cylinder yard reconstruction and operations under the no action alternative would require supplies of electricity, fuel, concrete, steel and other metals, and miscellaneous chemicals. The total quantities of commonly used materials would be small compared with local sources and would not affect local, regional, or national availability of these materials. No strategic or critical materials are expected to be consumed. The anticipated utilities requirements would be within the supply capacities at the Paducah site. The required material resources would be readily available.

5.1.2.9 Land Use

For the Paducah site, reconstruction of three storage yards within the boundaries of existing yards is planned, so additional land clearing would not be necessary. Therefore, impacts of the no action alternative on land use would be negligible.

5.1.2.10 Cultural Resources

Impacts to cultural resources under the no action alternative would not be likely at the Paducah site. The existing storage yards at Paducah are located in previously disturbed areas unlikely to contain cultural properties or resources listed on or eligible for listing on the NRHP. Three cylinder yards are scheduled for reconstruction at their existing locations. Cylinder breaches are not expected to result in HF or criteria pollutant emissions sufficient to impact cultural resources (see Section 5.1.2.3).

5.1.2.11 Environmental Justice

A review of the potential human health and safety impacts anticipated under the no action alternative indicates that no disproportionately high and adverse effects to minority or low-income populations are expected in the vicinity of the Paducah site during continued cylinder storage. Although such populations occur in certain areas on or within the 50-mi (80-km) radius used to identify the maximum geographic extent of human health impacts (see Section 3.1.12), no noteworthy impacts are expected. The results of accident analyses for the no action alternative also did not identify high and adverse impacts to the general public; the risk of accidents (consequence × probability) is less than 1 fatality for all accidents considered.

5.2 PROPOSED ACTION ALTERNATIVES

This section presents the estimated potential environmental impacts for the proposed action alternatives, including:

- Impacts from construction of the conversion facility at three alternative locations within the Paducah site (Section 5.2.1);
- Impacts from operation of the conversion facility at the three alternative locations (Section 5.2.2);
- Impacts from the transportation of uranium conversion products and waste materials to a disposal facility (Section 5.2.3);
- Impacts associated with the potential sale and use of HF and CaF_2 (Section 5.2.4);
- Impacts that would occur if the cylinders at ETTP were shipped to Paducah for conversion rather than to Portsmouth (Section 5.2.5); and
- Impacts from expanded plant operations, including extending the operational period and increasing throughput (Section 5.2.6).

In general, within each technical area, impacts are discussed for the construction and operation of the facility at the preferred location (Location A) as well as for two alternative locations (Locations B and C). The time period considered is a construction period of approximately 2 years and an operational period of 25 years.

5.2.1 Conversion Facility Construction Impacts

This section discusses the potential environmental impacts during construction of a conversion facility at the three alternative locations within the Paducah site. When completed, the conversion facility would occupy approximately 10 acres (4 ha), including process and support buildings and parking areas. However, up to 45 acres (18 ha) of land might be disturbed during construction, including temporary lay-down areas (areas for staging construction material and equipment or for excavated material) and for utility access. Some of the disturbed areas would not be adjacent to the construction area. The disturbed area includes access roads, rail lines, and utility corridors.

5.2.1.1 Human Health and Safety — Normal Construction Activities

5.2.1.1.1 Radiological Impacts. Three alternative locations at the Paducah site are considered for construction of the conversion facility (Figure 2.2-1). Location A is next to the current cylinder storage yards managed by DOE and is the preferred location for constructing the conversion facility. According to on-site radiation monitoring data, potential external radiation exposure also could be incurred by construction workers at Location C during construction activities because of the location's proximity to a USEC storage area. On-site radiation monitoring data near Location B are near background levels; thus, direct radiation from the cylinders would be negligible.

On the basis of the closest site monitoring data (DOE 2001b), direct external radiation would range from 0 to 0.035 mrem/h (data from thermoluminescence dosimeter [TLD]-1) across Location A and from 0 to 0.04 mrem/h (data from TLD-3) across Location C. The estimated external radiation exposure would be 35 mrem/yr for a hypothetical construction worker working 1,000 hours per year (4 hours per day and 250 days per year) at the spot of the highest radiation level within Location A. For a similar employee working within Location C, the potential dose would be about 40 mrem/yr. The potential doses were estimated on the basis of conservative assumptions; in reality, a worker would work at various spots around the project and would likely spend much less time than 1,000 hours per year at the same location. Furthermore, external radiation would be reduced by the construction of walls around the conversion facility. The radiation dose limit set to protect the general public from operations of the DOE facilities is 100 mrem/yr (DOE 1990); radiation workers are limited to a dose of 5,000 mrem/yr (10 CFR Part 835).

5.2.1.1.2 Chemical Impacts. Chemical exposures during construction at the Paducah site are expected to be low and mitigated by using personal protective equipment and engineering controls to comply with OSHA PELs that are applicable for construction activities. No differences between the three alternative locations are expected.

5.2.1.2 Human Health and Safety — Accidents

The risk of on-the-job fatalities and injuries to conversion facility construction workers would not depend on the location of the facility. The estimated injuries and fatalities were calculated by using industry-specific statistics from the BLS, as reported by the National Safety Council (2002). Annual fatality and injury rates from the BLS construction industry division were used for the 20-month construction phase. Construction of the conversion facility is estimated to require approximately 164 FTEs per year. For all three alternative locations, no on-the-job fatalities are predicted during the conversion facility construction phase; however, approximately 11 injuries are predicted (Table 5.2-1).

TABLE 5.2-1 Potential Impacts to Human Health from Physical Hazards during Conversion Facility Construction and Operations at the Paducah Site

	Impacts to Conversion Facility Workers[a]			
	Incidence of Fatalities		Incidence of Injuries	
Activity	Construction	Operations	Construction	Operations
Conversion to U_3O_8	0.04	0.14	11	197
Conversion to U_3O_8 (with ETTP cylinders)	0.04	0.16	11	221

[a] Potential hazards were estimated for all conversion facility workers over the entire construction (20 months) and operation (28 and 25 years, with and without ETTP cylinders, respectively) phases.

Source: Injury and fatality rates used in calculations were taken from National Safety Council (2002).

5.2.1.3 Air Quality and Noise

5.2.1.3.1 Air Quality Impacts. Currently, detailed information on the location of facility boundaries is available only for preferred Location A. For modeling air quality impacts at Locations B and C, the proposed facilities were assumed to be placed in the middle of the alternative locations.

Emissions of criteria pollutants — SO_2, NO_x (emissions are in NO_x but the ambient air quality standards are in NO_2), CO, and PM (PM_{10} and $PM_{2.5}$) — and of VOCs would occur during the construction period. These emissions would include fugitive dust emissions from earthmoving activities and exhaust emissions from heavy equipment and commuter/delivery vehicles. The annual emissions of criteria pollutants and VOCs expected during facility construction are presented in Table 5.2-2. Estimated maximum pollutant concentrations during construction are shown in Table 5.2-3 for the three alternative locations.

All of the pollutant concentration increments would remain below NAAQS and SAAQS. For SO_2, NO_2, and CO, concentration increments would be below 20% of their applicable standards. The highest concentration increment would occur for 24-hour average PM_{10}, which is predicted to be about 52% of the standard. Concentration increments for $PM_{2.5}$ are predicted to be less than 29% of the standard.

TABLE 5.2-2 Annual Criteria Pollutant and Volatile Organic Compound Emissions from Construction of the Conversion Facility at the Paducah Site

	Emission Rate (tons/yr)					
Emission Source	SO_2	NO_x	CO	VOCs	PM_{10}	$PM_{2.5}$
Exhaust	1.5	21.7	14.6	6.1	2.2	2.2[a]
Fugitive	–[b]	–	–	–	17.1[c]	2.5[c]

[a] For exhaust emissions, $PM_{2.5}$ emissions were conservatively assumed to be 100% of PM_{10} emissions.

[b] A dash indicates no emissions.

[c] Fugitive dust emissions were estimated under the assumption that the conversion facility construction area would continuously disturb about 9.1 acres (3.7 ha); this is the maximum amount of the approximately 10-acre (4-ha) facility footprint that would be disturbed at one time. A conventional control measure of water spraying with an emission control efficiency of 50% would be applied over the disturbed area. For fugitive dust emissions from earthmoving activities, $PM_{2.5}$ emissions were assumed to be 15% of PM_{10} emissions (EPA 2002).

Source: Folga (2003).

To obtain the total concentrations for comparison with applicable air quality standards, the modeled concentration increments were added to measured background values (given in Table 3.1-3). The total concentrations for SO_2, NO_2, and CO would be below 42% of their standards. The total concentrations for annual PM_{10} and 24-hour $PM_{2.5}$ are estimated to be 87% and 72% of their applicable standards, respectively. For all three alternative locations, total 24-hour PM_{10} and annual $PM_{2.5}$ concentrations would be above their applicable standards. In fact, annual average concentrations of $PM_{2.5}$ at most statewide monitoring stations either approach or are above the standard. PM (PM_{10} and $PM_{2.5}$) concentration increments at the site boundaries would be relatively high because the conversion facility would be constructed outside the current gaseous diffusion plant boundaries; thus, the general public would theoretically have access right at the conversion plant boundary.[2] Accordingly, construction activities should be conducted so as to minimize potential impacts on ambient air quality. Water could be sprayed on disturbed areas frequently, as needed, and dust suppressant or pavement could be applied to roads with frequent traffic.

[2] Formerly, the general public had access to the existing fenced boundaries. However, since the September 11, 2001, terrorist attack, site access for the general public has been restricted indefinitely to the DOE property boundaries.

TABLE 5.2-3 Maximum Air Quality Impacts at the Construction Site Boundary Due to Emissions from Activities Associated with Construction of the Conversion Facility at the Paducah Site

			Concentration ($\mu g/m^3$)				Percent of NAAQS/SAAQS[e]	
Location	Pollutant[a]	Averaging Time	Maximum Increment[b]	Back-ground[c]	Total[d]	NAAQS and SAAQS	Increment	Total
A	SO_2	3 hours	30.0	169	199	1,300	2.3	15.3
		24 hours	11.1	86	97.1	365	3.0	26.6
		Annual	1.3	13.3	14.6	80	1.7	18.3
	NO_2	Annual	19.9	22.6	42.5	100	19.8	42.4
	CO	1 hour	868	6,970	7,840	40,000	2.2	19.6
		8 hours	332	3,220	3,550	10,000	3.3	35.5
	PM_{10}	24 hours	78.0	79	157	150	52.0	105
		Annual	18.3	25	43.3	50	36.6	86.6
	$PM_{2.5}$	24 hours	15.1	31.1	46.2	65	23.3	71.1
		Annual	4.4	14.7	19.1	15	29.2	127
B	SO_2	3 hours	29.8	169	199	1,300	2.3	15.3
		24 hours	11.2	86	97.2	365	3.1	26.6
		Annual	1.3	13.3	14.6	80	1.7	18.3
	NO_2	Annual	19.8	22.6	42.4	100	19.8	42.4
	CO	1 hour	895	6,970	7,860	40,000	2.2	19.7
		8 hours	336	3,220	3,560	10,000	3.4	35.6
	PM_{10}	24 hours	75.4	79	154	150	50.3	103
		Annual	18.2	25	43.2	50	36.4	86.4
	$PM_{2.5}$	24 hours	15.2	31.1	46.3	65	23.4	71.3
		Annual	4.4	14.7	19.1	15	29.1	127
C	SO_2	3 hours	30.1	169	199	1,300	2.3	15.3
		24 hours	11.2	86	97.2	365	3.1	26.6
		Annual	1.3	13.3	14.6	80	1.7	18.3
	NO_2	Annual	19.8	22.6	42.4	100	19.8	42.4
	CO	1 hour	904	6,970	7,870	40,000	2.3	19.7
		8 hours	337	3,220	3,560	10,000	3.4	35.6
	PM_{10}	24 hours	77.6	79	157	150	51.7	104
		Annual	18.3	25	43.3	50	36.5	86.5
	$PM_{2.5}$	24 hours	15.5	31.1	46.6	65	23.8	71.6
		Annual	4.4	14.7	19.1	15	29.2	127

Footnotes on next page.

TABLE 5.2-3 (Cont.)

[a] Emissions are from equipment and vehicle engine exhaust, except for PM_{10} and $PM_{2.5}$, which are also from soil disturbance.

[b] Data represent the maximum concentration increments estimated, except that the fourth- and eighth-highest concentration increments estimated are listed for 24-hour PM_{10} and $PM_{2.5}$.

[c] See Table 3.1-3.

[d] Total equals maximum modeled concentration plus background concentration.

[e] The values in the next-to-last column are maximum concentration increments as a percent of NAAQS and SAAQS. The values in the last column are total concentration increments as a percent of NAAQS and SAAQS.

The potential impacts of PM (PM_{10} and $PM_{2.5}$) released from near-ground level would be limited to the immediate vicinity of the site boundaries — areas that the general public is expected to occupy only infrequently. The PM concentrations would decrease rapidly with distance from the source. At the nearest residence on McCall Road just east of the DOE boundary (about 1.3 km [0.8 mi] southeast of candidate Location C), predicted concentrations would be less than 5% of the highest concentration increments at the site boundaries.

Among the three alternative locations, potential air quality impacts due to construction activities would be similar, with the highest at Locations A and C, and the lowest at Location B, as shown in Table 5.2-3. However, as mentioned previously, the locations of facility boundaries for Locations B and C are assumed arbitrarily; thus, the results for the two alternative locations should be interpreted in that context.

5.2.1.3.2 Noise Impacts. Noise levels from construction would be similar among the alternative locations. During construction, the commuting/delivery vehicular traffic around the facilities would generate intermittent noise. However, the contribution to noise from these intermittent sources would be limited to the immediate vicinity of the traffic route and would be minor in comparison with the contribution from continuous noise sources such as compressors or bulldozers during construction. Sources of noise during construction of the conversion facility would include standard commercial and industrial activities for moving earth and erecting concrete and steel structures. Noise levels from these activities would be comparable to those from other construction sites of similar size.

The noise levels would be highest during the early phases of construction, when heavy equipment would be used to clear the site. This early phase of construction would be about 6 months of the entire construction period of 1.5 years. Average noise levels for construction equipment range from 76 dB(A) for a pump, to 85 dB(A) for a bulldozer, to 101 dB(A) at peak for a pile driver (Harris Miller Miller & Hanson, Inc. [HMMH] 1995). To estimate noise levels at the nearest residence, it was assumed that the two noisiest pieces of equipment would operate simultaneously. A scraper and a heavy truck operating continuously typically generate noise levels of 89 and 88 dB(A), respectively, at a distance of 15 m (50 ft) from the source (HMMH 1995),[3] which result in a combined noise level of about 91.5 dB(A) at a distance of 15 m (50 ft).

The nearest residence to alternative Locations A, B, and C would be the same one; it is located at McCall Road just off the DOE boundary. This residence, located about 1.3 km (0.8 mi) southeast of Location C, was selected as the receptor for the analysis of potential noise impacts. Noise levels decrease about 6 dB per doubling of distance from the point source because of the way sound spreads geometrically over an increasing distance. Thus, construction activities would result in estimated noise levels of about 53 dB(A) at the nearest residence. This level would be 48 dB(A) as DNL if it is assumed that construction activities would be limited to an 8-hour daytime shift. This 48-dB(A) estimate is below the EPA guideline of 55 dB(A) as DNL for residential zones (see Section 3.1.3.4), which was established to prevent interference with activity, annoyance, or hearing impairment. This 48-dB(A) estimate is probably an upper bound because it does not account for other types of attenuation, such as air absorption and ground effects due to terrain and vegetation. If only ground effects were considered (HMMH 1995), more than 10 dB(A) of attenuation would occur at the nearest residence, which would result in less than 38 dB(A), which is below background levels.

Most of these construction activities would occur during the day, when noise is tolerated better than at night, because of the masking effects of background noise. Nighttime noise levels would drop for all three alternative locations to the background levels of a rural environment because construction activities would cease at night.

5.2.1.4 Water and Soil

Construction of a conversion facility at the Paducah site would disturb land, use water, and produce liquid wastes. The following sections discuss impacts to surface water, groundwater, and soil resources at Paducah during construction. Because site-specific impacts were not identified, impacts to water and soil at alternative Locations A, B, and C would be the same.

5.2.1.4.1 Surface Water. Construction of a conversion facility at the Paducah site would produce increased runoff to nearby surface waters because soils and vegetation would be replaced with either buildings or paved areas. The amount of increased runoff from the new, impermeable land surface would be negligible (less than about 1.3% of the site area) compared with the existing area that contributes to runoff. None of the construction activities would measurably affect the existing floodplains.

Water would be required during construction. Peak water use would be 5,500 gal/d (20,800 L/d) or 2 million gal/yr (7.6 million L/yr). About 1,500 gal/d (5,700 L/d) of water would be used in actual construction; 4,000 gal/d (15,140 L/d) of water would be used by the

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[3] Pile drivers were excluded because piles would not be required for buildings at the site.

workforce. Construction water would be obtained from the Ohio River. If the rate of withdrawal was constant in time, about 3.8 gal/min (14 L/min) would be needed. This rate of withdrawal would be about 0.000003% of the mean flow in the Ohio River.

Wastewater would also be produced during construction. For the assumed workforce, about 4,000 gal/d (15,140 L/d) or 1.5 million gal/yr (5.7 million L/yr) of sanitary wastewater would be generated. There would be no sanitary wastewater discharged to the environment because portable toilets would be used.

5.2.1.4.2 Groundwater. Potential impacts to groundwater could occur during construction. These impacts could include changes in effective recharge to underlying aquifers, changes in the depth to groundwater, changes in the direction of groundwater flow, and changes in groundwater quality.

Because all water used at the Paducah site would be obtained from the Ohio River, there would be no direct impacts to groundwater recharge, depth, or flow direction from construction activities. However, these parameters could be minutely affected by changes in the permeability of the surface soil produced by construction activities and building and parking lot construction. Because of the small associated operational areas (less than 1.3% of the total site area), these changes would not be measurable. Similarly, the quality of groundwater beneath the selected site could be affected by surface construction activities through infiltration of surface water contaminated from spills of construction materials. These impacts would be indirect because there would be no direct releases of contaminants to groundwater. Indirect contamination could result from the mobilization of exposed chemicals by precipitation, followed by infiltration of contaminated runoff water. Following good engineering and construction practices and implementing storm water and erosion control measures would minimize impacts to groundwater quality.

5.2.1.4.3 Soils. Impacts to soil could occur during construction for the Paducah conversion facility. These impacts could include changes in topography, permeability, quality, and erosion potential.

All three of the alternative locations (A, B, and C) would be sufficiently large (35, 59, and 53 acres [14, 24, and 21 ha], respectively) to accommodate the conversion facility and most of the disturbed area (45 acres [18 ha]). Because the sites are relatively flat there would be no significant changes to topography, and the maximum amount of land needed for construction would be small relative to the total land available at the site (less than about 1.3%). Erosion potential would increase during construction; the impacts, however, would be local, temporary, and about the same for each of the three alternative locations.

Construction activities could also affect the quality of the land at the selected location for the conversion facility. Impacts on quality could result from spills and other construction activities that could release contaminants to the surface. Following good engineering and construction practices would minimize impacts to soil quality.

Contaminated soil associated with SWMU 194 could be excavated during construction at either Location A or B. Management of these soils is discussed in Section 5.2.1.7.

5.2.1.5 Socioeconomics

The socioeconomic analysis covers the effects of construction on population, employment, income, regional growth, housing, and community resources in the ROI around the Paducah site. Impacts from construction are summarized in Table 5.2-4. The socioeconomic impacts are not dependent on the location of the conversion facility; thus, the impacts would be the same for alternative Locations A, B, and C.

The potential socioeconomic impacts would be relatively small. It is estimated that construction activities would create direct employment of about 190 people in the peak construction year and about 100 additional indirect jobs in the ROI. Construction activities would increase the annual average employment growth rate by about 0.1 of a percentage point over the duration of construction. A conversion facility would produce about $10 million in personal income in the peak year of construction.

It is estimated that about 290 people would in-migrate to the ROI in the peak year of construction. However, in-migration would have only a marginal effect on population growth and would require only about 5% of vacant rental housing in the peak year. No significant impact on public finances would occur as a result of in-migration. Fewer than five local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in McCracken County.

TABLE 5.2-4 Socioeconomic Impacts from Construction of the Conversion Facility at the Paducah Site

Impact Area	Construction Impacts[a]
Employment	
Direct	190
Total	290
Income (millions of 2002 $)	
Direct	5.3
Total	9.5
Population (no. of new ROI residents)	290
Housing (no. of units required)	100
Public finances (% impact on fiscal balance)	
Cities in McCracken County[b]	0.3
McCracken County	0.2
Schools in McCracken County[c]	0.3
Public service employment (no. of new employees in McCracken County)[c]	
Police	0
Firefighters	0
General	1
Physicians	0
Teachers	1
No. of new staffed hospital beds in McCracken County	1

a Impacts are shown for the peak year of construction (2005).

b Includes impacts that would occur in the City of Paducah.

c Includes impacts that would occur in the McCracken County school district.

5.2.1.6 Ecology

Potential impacts to vegetation, wildlife, wetlands, and threatened and endangered species that would result from the construction of a conversion facility are described below. Additional information regarding wetlands and federally-listed species can be found in Van Lonkhuyzen (2004).

5.2.1.6.1 Vegetation. Existing vegetation within the disturbed area would be destroyed during land clearing activities. Construction of a conversion facility at any of the three alternative locations at the Paducah site is not expected to threaten the local population of any species. Replanting disturbed areas with native species would comply with Executive Order 13148, *Greening the Government through Leadership in Environmental Management* (U.S. President 2000). Erosion of exposed soil at construction sites could reduce the effectiveness of restoration efforts and create sedimentation downgradient of the construction site. However, the implementation of standard erosion control measures, installation of storm water retention ponds, and immediate replanting of disturbed areas with native species would help minimize impacts to vegetation. Deposition of fugitive dust resulting from construction activities could adversely affect vegetation; however, the use of control measures to reduce dust production could minimize impacts (see Section 5.2.1.3).

Constructing a facility at Location A, the preferred location, would result in the loss of approximately 10 acres (4 ha) of previously disturbed managed grassland vegetation that is maintained by frequent mowing. The facility would not replace undisturbed natural communities. Managed grassland comprises most of the vegetation on the Paducah site. The loss of 10 acres (4 ha) would therefore represent a minor decrease in this habitat on the Paducah site. This area represents about 29% of the area available at the 35-acre (14-ha) Location A. The total area of construction-related disturbance, however, would be approximately 45 acres (18 ha) in size. Although construction-related activities would primarily affect managed grassland vegetation, impacts to the wooded area at this location could also occur during the construction period, unless temporary construction areas, such as lay-down areas, were positioned outside the southern portion of Location A in adjacent, previously disturbed areas. If facility construction required the disturbance of all of Location A, the undisturbed mature deciduous forest at this location would potentially be eliminated. Although deciduous forest is not uncommon in the vicinity of the Paducah site, impacts to mature deciduous forest communities would generally be considered a greater adverse impact than those to managed grassland because of the (1) undisturbed condition of mature forest, (2) high biodiversity and habitat value, and (3) considerably greater length of time required for restoration of mature forest. The construction of utility lines and rail lines would extend beyond Location A and would result in additional impacts to vegetation. Construction of rail lines west of Location A would affect previously disturbed areas supporting both managed grassland and scrub-shrub communities within the existing railroad bed. Mature deciduous hardwood forest adjacent to the railroad bed could be affected by the construction of the new rail line if construction-related activities occur beyond the railroad bed.

The specific vegetation communities impacted by construction at Location B would depend on the placement of the facility within the available area. A facility of 10 acres (4 ha) would occupy 17% of the area available at this 59-acre (24-ha) location. Placement of the facility at the northern end of Location B would primarily result in impacts to areas that are predominantly already disturbed and support managed grassland vegetation (consisting of 38 acres [15 ha]). The groves of mature trees in this area might be affected by facility construction. However, depending on the placement of the facility, these impacts might be avoided. Avoidance of the tree groves during construction might not be possible unless temporary construction areas were positioned outside Location B in adjacent, previously disturbed areas. Impacts to the undisturbed mature deciduous forest at Location B may be avoided, although impacts would be expected to occur if facility construction required the disturbance of 45 acres (18 ha) of this location.

The specific vegetation communities impacted by construction at Location C would also depend on the placement of the facility within the available area. A facility of 10 acres (4 ha) would occupy 19% of the area available at this 53-acre (21-ha) location. Placement of the facility in the western portion of this location (west of Dyke Road) would primarily impact a previously disturbed immature deciduous forest community. Facility placement in the eastern portion of the location would impact primarily old-field open grassland community, with likely impacts to the small groves of mature trees in this area. Facility construction would disturb a total area of up to 45 acres (18 ha) and potentially result in impacts to both deciduous forest and grassland areas.

5.2.1.6.2 Wildlife. Wildlife would be disturbed by land clearing, noise, and human presence. Wildlife with restricted mobility, such as burrowing species or juveniles of nesting species, would be destroyed during land clearing activities. More mobile individuals would relocate to adjacent available areas with suitable habitat: abundant habitat is available on the Paducah site and the adjacent West Kentucky Wildlife Management Area. Population densities, and thus competition for food and nesting sites, would increase in these areas, potentially reducing the survivability or reproductive capacity of displaced individuals. Some wildlife species would be expected to recolonize replanted areas near the conversion facility following completion of construction. Construction of a conversion facility at any of the three alternative locations at the Paducah site is not expected to threaten the local population of any wildlife species because similar habitat would be available in the vicinity of the site.

Constructing a conversion facility at Location A would primarily impact those species commonly associated with managed grasslands maintained by frequent mowing; however, larger areas of similar habitat would be available nearby. Construction could also impact habitat for species associated with mature deciduous forest, such as neotropical migratory birds, unless temporary construction areas were positioned outside the southern portion of Location A in previously disturbed areas. Noise associated with construction activities up to 79.5 dB(A) at 60 m (200 ft) may reduce the suitability of the forest habitat at Location A for some species during the construction period. The construction of utility lines and rail lines would result in additional impacts to wildlife habitat. Habitat for species associated with both managed grassland and scrub-shrub communities within the existing railroad bed could be lost during construction of rail lines west of Location A. If construction-related activities occur beyond the railroad bed, species supported by mature deciduous hardwood forest could be affected. In addition, noise associated with rail construction might reduce the suitability of the forest habitat for some species.

Constructing a conversion facility in the northern portion of Location B would impact habitat for those species commonly associated with frequently mowed grasslands and other disturbed areas, such as along drainage channels. Similar habitat would be abundant in other areas of the Paducah site. Impacts to habitat for species associated with mature deciduous forest could likely be avoided by placing the facility in the northern portion of this location. Construction of a facility immediately adjacent to the forest could reduce that habitat's suitability for some wildlife species. Species that occur in the tree groves at this location, such as neotropical migratory birds, might be impacted during construction; however, impacts may potentially be avoided if temporary construction areas were positioned outside Location B in adjacent disturbed areas. If facility construction required the disturbance of 45 acres (18 ha) of this location, however, impacts to the mature forest habitat at Location B would be expected to occur.

Species associated with deciduous forest or open grassland habitat could be impacted by construction of a conversion facility at Location C. Construction west of Dyke Road would primarily impact forested habitat, while construction in the eastern half would impact old field grassland habitat. In addition, species such as neotropical migratory birds, which are associated with the groves of mature trees in the eastern half of this location, would likely be impacted by construction in that area. Although these habitats are not uncommon in the vicinity of the Paducah site, open grassland areas provide opportunities for restoration of native prairie habitat. Construction of a conversion facility at Location C may decrease the suitability of the remainder of the location for some wildlife species.

5.2.1.6.3 Wetlands. Wetlands could potentially be impacted by filling or draining during construction of a conversion facility. Wetlands could be impacted by alteration of surface water runoff patterns, soil compaction, or groundwater flow if the conversion facility was located immediately adjacent to wetland areas. Impacts to wetlands would be minimized, however, by maintaining a buffer area around them during facility construction. Executive Order 11990, *Protection of Wetlands* (U.S. President 1977a), requires federal agencies to minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial uses of wetlands. 10 CFR Part 1022 sets forth DOE regulations for implementing Executive Order 11990 as well as Executive Order 11988, *Floodplain Management* (U.S. President 1977b). Mitigation for unavoidable impacts may be developed in coordination with the appropriate regulatory agencies. Unavoidable impacts to wetlands within the jurisdiction of the USACE might require a CWA Section 404 Permit, which would trigger the need for a CWA Section 401 Water Quality Certification from the Commonwealth of Kentucky. An approved mitigation plan might be required prior to the initiation of construction.

Water-level changes in the Ohio River because of water withdrawal for construction would be negligible. Regional groundwater changes due to the increase in impermeable surface related to facility construction would also be negligible. Therefore, except for the potential local indirect impacts noted above, impacts to regional wetlands due to changes in groundwater or surface water levels or flow patterns would be expected to be negligible.

Construction of a conversion facility at Location A could result in impacts to wetlands located in the central and southern portion of this location (Figure 5.2-1). Although the wetlands within the open, previously disturbed area are outside of the facility footprint, construction of access roads and rail lines could eliminate a portion of the wetlands in this area. The larger, undisturbed forested wetland in the southern portion of Location A, however, could likely be avoided. Two new rail lines, an access road from Patrol Road A, and a walkway leading from the south parking area to Building C1100, would cross the wetland within the drainage swale leading to KPDES Outfall 017 and Bayou Creek. Direct impacts to this wetland could occur from the placement of fill material and culverts for the crossings.

Impacts could also occur to the wetlands located in drainage swales to the south, which would be crossed by a new rail line and an access road from Patrol Road 4. In addition, two small isolated wetlands in the open, grassy area could be filled as a result of the construction of the rail line and access road. The drainage swale along the south margin of Patrol Road 4 may be impacted if widening or other improvements to that road are made, and impacts to wetlands in drainages along the Entrance Highway could potentially result from improvements to the adjacent roadway to the east. Approximately 6,900 ft^2 (640 m^2) of palustrine emergent wetland would likely be eliminated by culvert construction or direct placement of fill material within Location A. Wetland areas that are not filled may be indirectly affected by an altered hydrologic regime, due to the proximity of construction, possibly resulting in a decreased frequency or duration of inundation or soil saturation and potential loss of hydrology necessary to sustain wetland conditions. Indirect impacts could be minimized by maintaining a buffer near adjacent wetlands. In addition, placement of temporary construction areas outside Location A might be necessary to avoid additional direct or indirect impacts to these wetlands.

The increase in impervious surface and discharge of storm water runoff, due to construction of a conversion facility, could result in alteration of hydrology in the drainage system within Location A or downstream in Bayou Creek, with greater fluctuations in high and low flows, as well as in the other headwater drainages immediately west of the Entrance Highway. However, because only a small portion of the Bayou Creek watershed would be involved, impacts would likely be small. Downstream wetlands could be affected by sedimentation during construction; however, the implementation of erosion control measures would reduce the likelihood of such impacts. The total area of construction-related disturbance would be up to 45 acres (18 ha). The forested wetland at this location could be impacted unless temporary construction areas were positioned outside the southern portion of Location A in adjacent, previously disturbed areas.

Wetlands could also be impacted by the construction of infrastructure for facility utility requirements or new rail lines extending outside of Location A. Although the rail lines would primarily be constructed on an existing railroad bed, wetlands in drainages along the margin of the rail bed, forested wetlands adjacent to the south margin east of Bayou Creek, or forested wetlands along each side of the rail bed west of Bayou Creek could be impacted if rail bed

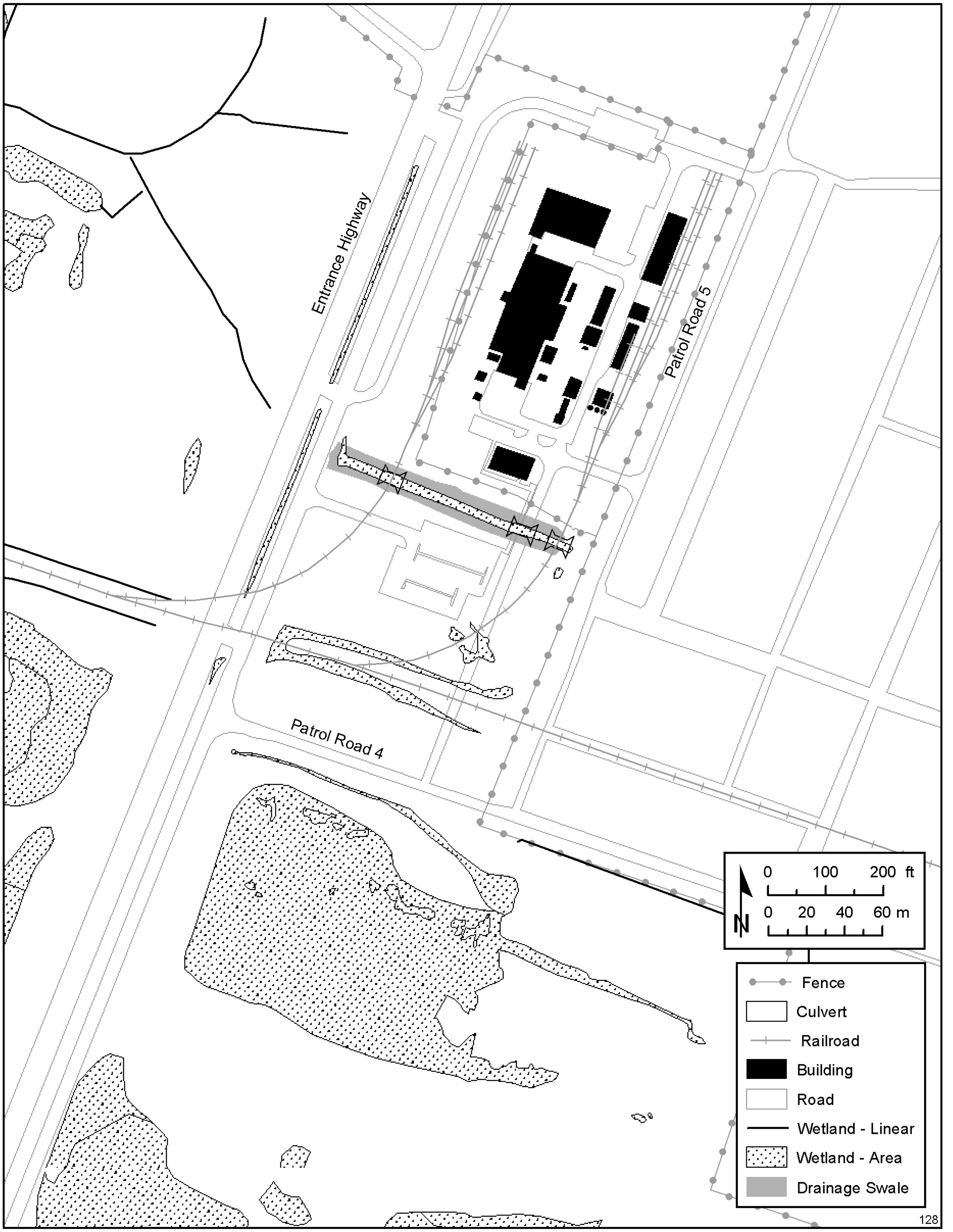

FIGURE 5.2-1 Wetlands within Location A at the Paducah Site

repairs or reconstruction are necessary, or by the operation of heavy equipment within these wetlands while laying track (Figure 5.2-2). The drainage along the north side of the rail bed, just west of the Entrance Highway, may potentially be affected by construction of the new rail line serving the western portion of the conversion facility. In addition, impacts to Bayou Creek and adjacent wetlands could result from reconstruction of the rail bridge crossing Bayou Creek; however, wetland impacts from replacement of bridge supports would be expected to be small.

Construction of a conversion facility at Location B might also impact wetlands. Placement of a facility in the northern, disturbed portion of this location would minimize wetland impacts and avoid impacts to the forested wetlands in the southern portion. However, the drainage channels in the northern area would likely be impacted. The channels could be rerouted to continue to convey flows to Bayou Creek. Wetlands could also be impacted by the construction of infrastructure for facility utility requirements, transportation corridors from cylinder storage yards, or rail lines. In addition, placement of temporary construction areas outside Location B may be necessary to avoid additional direct or indirect impacts to wetlands, including forested wetlands in the southern portion of this location. Indirect impacts to wetlands could also occur. The hydrologic characteristics of wetlands could be indirectly affected by adjacent construction, possibly resulting in a decreased frequency or duration of inundation or soil saturation. Indirect impacts could be minimized by maintaining a buffer near adjacent wetlands. Facility construction could result in alteration of hydrology in the drainage system within Location B, or downstream in Bayou Creek, with greater fluctuations in high and low flows. However, because of the small portion of the watershed involved, impacts would likely be small. Downstream wetlands could be impacted by sedimentation during construction; however, the implementation of erosion control measures would reduce the likelihood of such impacts.

Construction of a facility at Location C could potentially result in impacts to wetlands. Facility placement in the western or northeastern portions of this location would likely result in direct impacts to wetlands. Placement of a facility in the southeastern portion of Location C may best avoid direct impacts to wetlands; however, wetlands located in drainage ditches along Dyke Road may be impacted. Indirect impacts, however, could result from construction of a facility immediately adjacent to wetlands in this area. The total area disturbed during construction would be up to 45 acres (18 ha), resulting in direct impacts unless temporary construction areas were located outside of Location C. Facility construction could result in alteration of hydrology in the drainage channel southeast of Location C, or downstream in Little Bayou Creek, with greater fluctuations in high and low flows. However, because of the small portion of the watershed involved, impacts would likely be small. Downstream wetlands could be impacted by sedimentation during construction; the likelihood of such impacts would be reduced, however, with the implementation of erosion control measures.

5.2.1.6.4 Threatened and Endangered Species. Construction of a conversion facility at Location A is not expected to directly impact federal- or state-listed species. However, impacts to deciduous forest may occur unless temporary construction areas were positioned outside the southern portion of Location A. Trees with exfoliating bark, such as shagbark hickory or dead trees with loose bark, could potentially be used by the Indiana bat (federal- and state-listed as

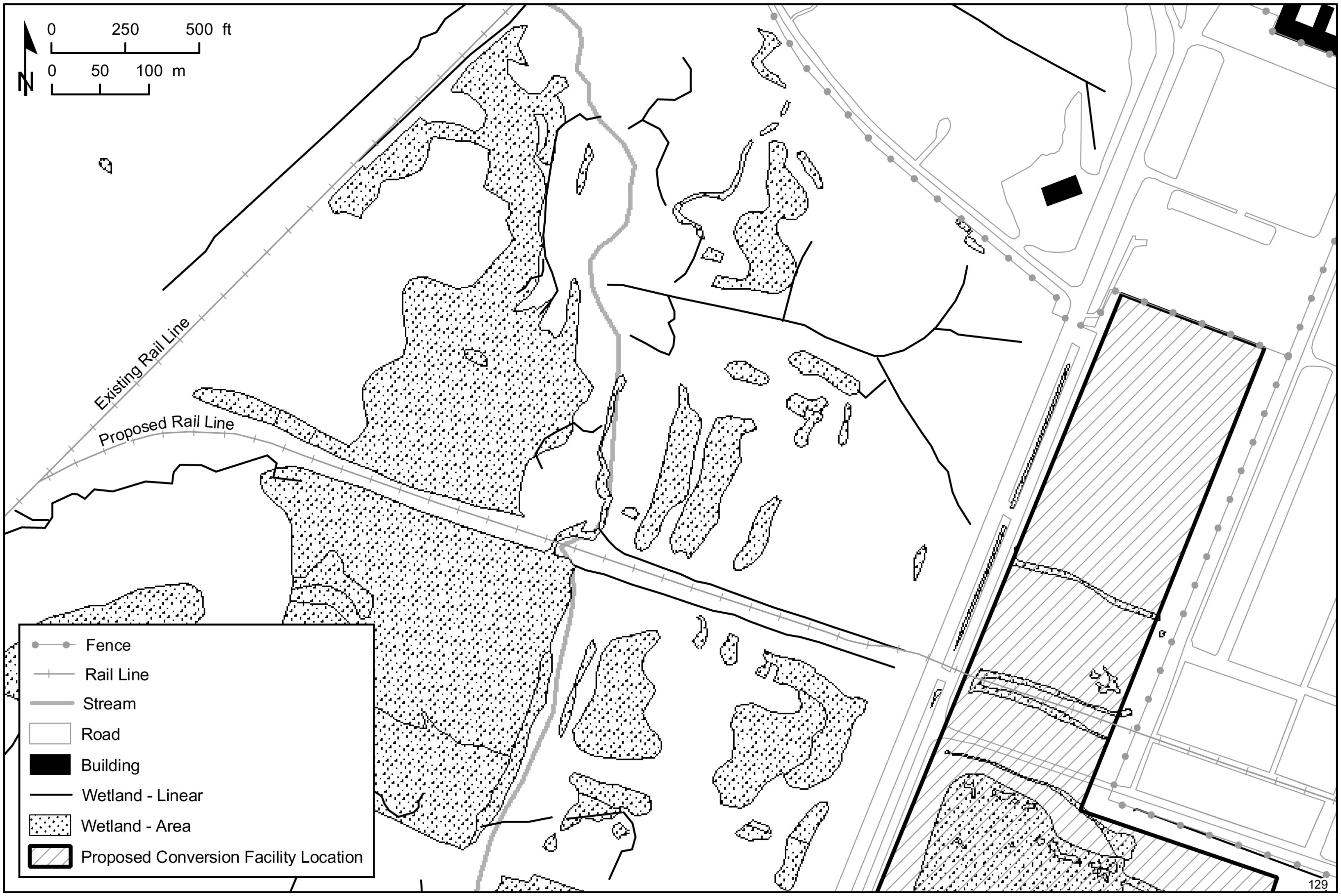

FIGURE 5.2-2 Wetlands along the Proposed Rail Line at the Paducah Site

endangered) as roosting trees during summer, although the forested area at the southern portion of Location A has not been identified as summer habitat. If trees (either live or dead) with exfoliating bark were encountered on construction areas, they should be saved if possible. If necessary, the trees should be cut only before March 31 or after October 15 to avoid the period when they might be used by Indiana bats, according to recommendations of the U.S. Fish and Wildlife Service (USFWS) (Andrews 2004).

Disturbance due to increased noise, lighting, and human presence during construction could decrease the quality of mature forested habitats for the Indiana bat. However, Indiana bats using habitat near the Paducah site would be currently exposed to noise and other effects of human disturbance. Consequently, these effects related to construction activities would be expected to be minor. Construction of the conversion facility or new rail lines in Location A could disturb Indiana bats that may use the forested area in the southern portion of that location. In addition, construction of rail lines adjacent to the mature deciduous forest habitats west of Entrance Highway could likely disturb Indiana bats. In addition to trees east of Bayou Creek that might potentially be used by Indiana bats (such as in or near Location B), portions of the forested area west of the creek are identified as fair quality Indiana bat habitat (Figure 5.2-3), with additional areas identified as poor potential habitat. Because good Indiana bat habitat is not available in that immediate area, bats might likely be disturbed in, or prevented from using, the fair quality habitat.

Impacts to the forested area at Location B could likely be avoided; however, construction of a conversion facility in the southern portion of Location B could result in the removal of trees potentially used by Indiana bats and indirectly impact the Indiana bat by reducing the quality of potential habitat west of Bayou Creek. Construction activities and the presence of a facility in proximity to potential habitat may decrease the suitability of these areas for summer habitat.

Impacts to either the forested area or groves at Location C could occur and result in the removal of trees potentially used by Indiana bats. Construction in the eastern portion of Location C could impact potential habitat for cream wild indigo (state-listed as a species of special concern) and compass plant (state-listed as threatened). Although these species are not known to occur at or near this location, current restoration efforts are increasing the suitability of the open grassland habitat for these species. Impacts to wetlands with open water, such as the drainage channels in Location B or the small ponds in the eastern portion of Location C, could reduce habitat for the great blue heron (state-listed as a species of special concern).

5.2.1.7 Waste Management

Potential waste management impacts for construction were evaluated by determining the types and estimating the volumes of wastes that would be generated. These estimates were then compared with projected site generation volumes.

Construction of the facility would generate both hazardous and nonhazardous waste. Hazardous waste would be sent to off-site permitted contractors for disposal. Nonhazardous

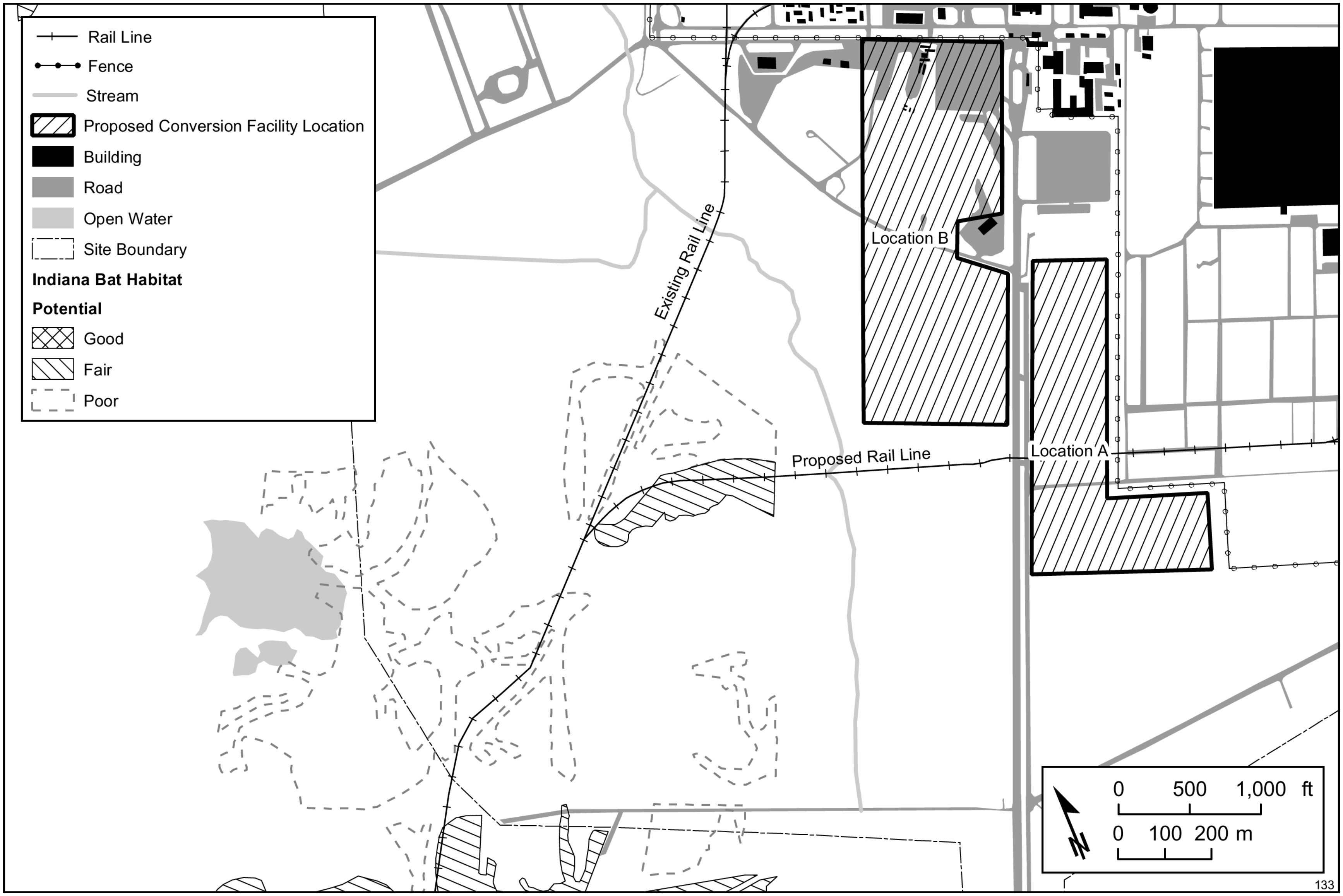

FIGURE 5.2-3 Areas of Potential Indiana Bat Habitat at the Paducah Site

waste would be disposed of on site at a state-permitted landfill. Table 5.2-5 presents the total waste volumes that would be generated. No radioactive waste would be generated during the construction phase of the conversion facility. Overall, only minimal waste management impacts would result from construction-generated wastes.

In addition to construction-related waste that would be generated, potentially contaminated soil could be excavated during construction of the facility at either Location A or B at Paducah. On the basis of SWMU 194 investigation results and the site characterization report for Location A (Tetra Tech, Inc. 2000), contaminated soil may be located at both locations (see Section 3.1.4.2). The excavated soil would be managed consistent with RCRA regulations and coordinated between the Commonwealth of Kentucky (Division of Waste Management) and DOE.

TABLE 5.2-5 Wastes Generated from Construction Activities for the Conversion Facility at the Paducah Site[a]

Waste Category	Volume
Hazardous waste	115 m^3
Nonhazardous waste	
Solids	700 m^3
Wastewater	3.8×10^6 L
Sanitary wastewater	1.1×10^7 L

[a] Total waste generated during a construction period of 2 years. Because data were not available for the UDS conversion facility, data developed for the DUF_6 PEIS (Dubrin et al. 1997) were used.

5.2.1.8 Resource Requirements

The resources required for facility construction would not depend on the location of the facility. Materials related to construction would include concrete, sand, gravel, steel, and other metals (Table 5.2-6). At this time, no unusual construction material requirements have been identified. The construction resources, except for those that could be recovered and recycled with current technology, would be irretrievably lost. None of the identified construction resources is in short supply, and all should be readily available in the local region.

Small to moderate amounts of specialty materials (i.e., Monel and Inconel) would be required for construction of the conversion facility in quantities that would not seriously reduce the national or world supply. This material would be used throughout the facilities and is used in the generation of HF in the conversion process. The autoclaves and conversion units (process reactors) are long-lead-time procurements with few qualified bidders. Many suppliers are available for the remainder of the equipment.

5.2.1.9 Land Use

The preferred location for the facility (Location A) covers approximately 35 acres (14 ha) and consists primarily of a grassy field, with a wooded area in the southeastern section of the tract. Although constructing a conversion facility at this location would involve modifying existing land use on the specified tract, the resulting facility would be consistent with the heavy

TABLE 5.2-6 Materials/Resources Consumed during Construction of the Conversion Facility at the Paducah Site

Materials/Resources	Total Consumption	Unit	Peak Demand	Unit
Utilities				
Water	4×10^6	gal	1,500	gal/h
Electricity	1,500	MWh	7.2	MWh/d
Solids				
Concrete	9,139	yd^3	NA[a]	NA
Steel	511	tons	NA	NA
Inconel/Monel	33	tons	NA	NA
Liquids				
Fuel	73,000	gal	250	gal/d
Gases				
Industrial gases (propane)	15,000	gal	50	gal/d

[a] NA = not applicable.

industrialized land use currently found at the Paducah site — a consequence of producing enriched uranium and its DUF_6 by-product. As a consequence, at most, negligible land use impacts are anticipated as a result of constructing the facility at Location A.

Constructing a conversion facility on either of the two other locations being considered would have land use impacts similar to those from construction on Location A. Both locations are slightly larger than Location A; Location B covers about 59 acres (23 ha) and Location C covers roughly 53 acres (21 ha), with both comprising largely undeveloped tracts on the Paducah site. As with Location A, constructing a conversion facility on either of these alternate locations would require modifying existing land use on the tract of land involved; however, the resulting facility would be consistent with the heavy industrialized land use currently found at the Paducah site. Once again, at most, negligible land use impacts are anticipated from constructing the facility.

5.2.1.10 Cultural Resources

Construction could potentially impact cultural resources. Neither an archaeological nor an architectural survey has been completed for the Paducah site as a whole or for any of the alternative locations, although an archaeological sensitivity study has been conducted (see Section 3.1.11). Consultations with the SHPO and Native American groups regarding traditional Native American cultural properties at these locations have been initiated (see Appendix G). In accordance with Section 106 of the National Historic Preservation Act of 1966, the adverse effects of this undertaking must be evaluated once a location is chosen.

- *Location A.* While no archaeological survey has been completed for Location A, the southern, undisturbed portion of this location has a “low” to “very low” archaeological sensitivity index (U.S. Department of the Army 1994b). Although a low sensitivity index suggests a low probability for encountering significant archaeological resources in Location A, further archaeological analysis would be required if this location was chosen and the southern undisturbed portion was disturbed. If significant archaeological resources were discovered or if traditional properties were identified, a mitigation plan must be prepared and executed in consultation with the Kentucky SHPO and appropriate Tribal governments.

- *Location B.* Location B has not been surveyed for archaeological resources but contains areas of high archaeological sensitivity overlooking Bayou Creek (U.S. Department of the Army 1994b) and a standing structure. An additional cultural resource survey would be required in consultation with the Kentucky SHPO if this location was chosen. If archaeological sites were encountered and determined to be significant, or if the known structure proved to be historically significant, or if traditional cultural properties were identified, a mitigation plan must be prepared and executed in consultation with the Kentucky SHPO and appropriate Tribal governments.

- *Location C.* About 50% of Location C has undergone an archaeological survey. No archaeological sites were recorded in the surveyed area, and the remainder of the location has “low” to “very low” archaeological sensitivity. The access roads that lead to this location would have to be widened if this location was chosen as the site for the conversion facility. A small segment of Dyke Road borders land with high archaeological sensitivity (U.S. Department of the Army 1994b). If this location was chosen, an archaeological survey of the unsurveyed portion of the location and areas likely to be affected by road widening would have to be completed. If significant archaeological resources were encountered or if traditional cultural properties were identified, mitigation plans must be prepared and executed in consultation with the Kentucky SHPO and appropriate Tribal governments.

5.2.1.11 Environmental Justice

The evaluation of environmental justice impacts associated with construction is based on the identification of high and adverse impacts in other impact areas considered in this EIS, followed by a determination of whether those impacts would affect minority and low-income populations disproportionately. Disproportionate impacts could take two forms: (1) when the environmental justice population is present at a higher percentage in the affected area than in the reference population (i.e., the state in which a potentially impacted population occurs), and (2) when the environmental justice population is more susceptible to impacts than the population as a whole. In either case, high and adverse impacts are a necessary precondition for environmental justice concerns in an EIS.

Analyses of construction-related impacts under the proposed action do not indicate the presence of high and adverse impacts for any of the other impact areas considered in this EIS (see Section 5.2.1). Despite the presence of disproportionately high percentages of both minority and low-income populations within 50 mi (80 km) of the site, no environmental justice impacts from constructing a conversion facility at the Paducah site are anticipated for Locations A, B, or C. Similarly, no evidence indicates that minority or low-income populations would experience high and adverse impacts from the proposed construction in the absence of such impacts in the population as a whole.

5.2.2 Operational Impacts

This section discusses the potential environmental impacts during operation of a conversion facility at the three alternative locations within the Paducah site. During normal operations, the facility would emit only small amounts of contaminants through air emissions; no contaminated liquid effluents would be produced during the dry conversion process. The operational period would be 25 years. If the ETTP cylinders were transported to and converted at Paducah (considered as an option), the operational period would be 28 years.

5.2.2.1 Human Health and Safety — Normal Facility Operations

5.2.2.1.1 Radiological Impacts. Radiological impacts to involved workers during normal operation of the conversion facility would result primarily from external radiation from the handling of depleted uranium materials. Potential impacts to noninvolved workers and members of the public would result primarily from trace amounts of uranium compounds released to the environment. Impacts to involved workers, noninvolved workers, and the general public would be similar for the three alternative locations. Background information on radiation exposure is provided in Chapter 4; details on the methodologies are provided in Appendix F.

Radiation exposures of the involved workers in the conversion facility were estimated on the basis of the measurement data on worker exposures in the Framatome ANP, Inc., facility in Richland, Washington. The Framatome ANP facility uses a dry conversion process to convert UF_6 into uranium oxide and has been in operation since 1997. UDS would implement a similar conversion technology in the Paducah facility, and the key components would be similar to those of the Framatome facility. Therefore, conditions for potential worker exposures at Paducah are expected to be similar to those at Framatome. However, the annual processing rate of uranium at Paducah (50 t [55 tons] per day) would be greater than that of Framatome (9 t [10 tons] per day). To process more uranium materials, four conversion lines would be installed, and more workers or longer work hours from each worker would be required. On the other hand, the specific activity of the uranium materials handled at Framatome (about 3.5×10^6 pCi/g [Edgar 1994]) is greater than that of depleted uranium (about 4.0×10^5 pCi/g). Consequently, the total radiological activities contained in each key component at Paducah would be less than those at Framatome, resulting in a smaller radiation dose rate from each component at Paducah. Because the actual worker activities and the activity duration and frequencies are not available for the conversion facility at this time, using worker exposure data from the Framatome facility is expected to provide a reasonable estimate of the potential radiation exposures of the involved workers at the Paducah facility. According to UDS (2003a,b), the conversion process would be very automated; therefore, the requirement of working at close distances to radiation sources would be limited. Potential radiation exposures of workers would be monitored by a dosimetry program and be kept below the regulatory limit. The implementation of ALARA practices would further reduce the potential for exposures.

Potential radiation exposures of the involved cylinder yard workers would result mainly from maintenance of both DUF_6 and non-DUF_6 cylinders and preparing and transferring DUF_6 cylinders to the conversion facility. Under the action alternatives, cylinder maintenance activities during the 25-year conversion period would most likely be the same as those currently being implemented, except that the number of DUF_6 cylinders would decrease steadily from the current level. Therefore, potential radiation exposures caused by maintenance activities were estimated by scaling the cylinder yard exposure data.

Potential exposures resulting from transferring cylinders to the conversion facility were estimated using the following assumptions: (1) retrieving each cylinder onto transportation equipment would require two workers to each work half an hour at a distance of 3 ft (1 m) from the cylinder, (2) inspecting a cylinder would require two workers to each work half an hour at a distance of 1 ft (0.30 m) from the cylinder, and (3) each transfer from the cylinder yard to the conversion facility would require two workers for about half an hour at a distance of 6 ft (2 m) from the cylinders. These assumptions were developed for the purpose of modeling potential radiation exposures; in actuality, preparing and transferring cylinders would probably take less time and involve fewer workers. As a result, radiation doses estimated on the basis of these assumptions are conservative.

Noninvolved workers would be those who would work in the conversion facility but would not perform hands-on activities, and those who would work elsewhere on the Paducah site. Depending on the location of the conversion facility, the location of the MEI would be different, and the associated radiation exposure might also vary. However, according to the previous analyses in the DUF_6 PEIS and the small uranium emission rate provided by UDS (2003b) for the conversion facility, potential radiation exposures of the noninvolved workers would be very small. An estimate of the bounding exposure, on the basis of the estimated maximum downwind air concentrations, is provided for the MEI in this section. According to the estimated bounding exposure, which is less than 1×10^{-5} mrem/yr, it is anticipated that the potential collective exposure of the noninvolved workers would also be very small and would be less than the product of the bounding MEI dose and the number of the noninvolved workers.

The location of the conversion facility within the Paducah site would have very little impact on collective exposures of the off-site public because of the much larger area (a circle with a radius of 50 mi [80 km]) considered for the collective exposures than the area of the Paducah site. The estimate of the collective exposure was obtained by using the emission rate (< 0.25 g/yr for uranium) provided by UDS (2003b) and the population distribution information obtained from the 2000 census. The actual location of the off-site public MEI would depend on the selected location of the conversion facility and the site boundary. The potential exposure would be bounded by the exposure associated with the maximum air concentrations, which are the same as those used for estimating the bounding exposure of the noninvolved worker MEI. The bounding exposure of the off-site public MEI would be greater than that of the noninvolved worker MEI because of the longer exposure duration (8,760 h/yr versus 2,000 h/yr) assumed for the off-site public than for the noninvolved workers, and because of consideration of the food ingestion pathway for the general public (see Appendix F for more detailed information).

As discussed in Chapter 1 and Appendix B, some portion of the DUF_6 inventory contains TRU and Tc contamination. The TRU materials and most of the Tc material are expected to remain in the emptied cylinders after the withdrawal of DUF_6. A small quantity of Tc might become vaporized and end up in the conversion process equipment, having been converted to technetium oxide. However, airborne emission of Tc is not anticipated because the oxide particles would be captured in the U_3O_8 product. The contribution to the potential external radiation exposures from these contaminants under normal operations were evaluated on the basis of bounding concentrations presented in Appendix B. The dose from these contaminants was estimated and compared with the dose from the depleted uranium and uranium decay products in the DUF_6. It is estimated that under normal operational conditions, the TRU and Tc contaminants would result in a very small contribution to the radiation doses to the involved workers — approximately 0.2% of the dose from the depleted uranium and its decay products.

Estimated potential annual radiation exposures and the corresponding estimates of potential LCFs of the various receptors as a result of normal operations of the conversion facility are presented in Table 5.2-7 (impacts would be the same for all three alternative locations). The average individual dose for involved workers in the conversion facility is estimated to be about 75 mrem/yr (UDS 2003b). The average individual dose for workers working at the cylinders yards was estimated to range from about 430 to 690 mrem/yr, assuming a total of eight workers each year (UDS 2003b). The larger exposure corresponds to the first year of conversion operations and the smaller exposure corresponds to the last year of operations. The estimated average doses for the involved workers are well below the dose limit of 5,000 mrem/yr set for radiation workers (10 CFR Part 835). The corresponding latent cancer risk for an average cylinder yard worker would be about 3×10^{-4} per year (1 chance in 3,300 of developing 1 LCF per year) or less. UDS has proposed 30 workers for cylinder management activities; therefore, the actual average dose and risk to individual workers would likely be less than the above estimated values that are based on 8 workers.

Collective exposures of the involved workers would depend on the number of workers required in the conversion facility. The estimated number of involved workers in the Paducah facility would be about 142 (UDS 2003b). The total collective exposure of the involved workers would then be about 10.7 person-rem/yr. The collective exposure of the cylinder yard workers is expected to range from 5.5 person-rem/yr for the first year of conversion operation to 3.4 person-rem/yr for the last year of conversion operation. Excess LCFs estimated for all the involved workers (both in the conversion facility and in the cylinder yards) would be less than 6×10^{-3}/yr (i.e., 1 chance in 160 of developing 1 LCF per year).

TABLE 5.2-7 Estimated Radiological Doses and Cancer Risks under Normal Conversion Facility Operations at the Paducah Site[a]

	Receptors					
	Involved Workers[b]		Noninvolved Workers[c]		General Public	
Locations	Average Dose/Risk (mrem/yr)/(risk/yr)	Collective Dose/Risk (person-rem/yr)/ (fatalities/yr)	MEI Dose/Risk[d] (mrem/yr)/ (risk/yr)	Collective Dose/Risk (person-rem/yr)/ (fatalities/yr)	MEI Dose/Risk[e] (mrem/yr)/ (risk/yr)	Collective Dose/Risk[f] (person-rem/yr)/ (fatalities/yr)
Radiation doses						
Conversion facility	75	10.7	$< 1.0 \times 10^{-5}$	$< 1.9 \times 10^{-5}$	$< 3.9 \times 10^{-5}$	4.7×10^{-5}
Cylinder yards	430 – 690	3.4 – 5.5	–[g]	–	–	–
Cancer risks						
Conversion facility	3×10^{-5}	4×10^{-3}	$< 5 \times 10^{-12}$	$< 1 \times 10^{-8}$	$< 2 \times 10^{-11}$	2×10^{-8}
Cylinder yards	2×10^{-4}– 3×10^{-4}	1×10^{-3}– 2×10^{-3}	–	–	–	–

[a] Impacts are reported as best estimates or bounding values. They are the same regardless of the location of the conversion facility.

[b] Involved workers are those workers directly involved with handling radioactive materials. For the conversion facility, 142 involved workers were assumed. Calculation results are presented as average individual dose and collective dose for the worker population.

[c] Noninvolved workers include individuals who work at the conversion facility but are not directly involved in handling materials, and individuals who work at the Paducah site but not within the conversion facility. The population size of noninvolved workers is about 1,900.

[d] The noninvolved worker MEI doses are the bounding estimates corresponding to the estimated maximum downwind air concentrations. The exposures would result from inhalation, external radiation, and incidental soil ingestion.

[e] The general public MEI doses are the bounding estimates corresponding to the estimated maximum downwind air concentrations. The exposure would result from inhalation; external radiation; and ingestion of plant foods, meat, milk, and soil.

[f] Collective exposures were estimated for the population (about 520,000 persons) within a 50-mi (80-km) radius around the Paducah site. The exposure pathways considered were inhalation; external radiation; and ingestion of plant foods, meat, milk, and soil.

[g] A dash indicates that potential air emissions from cylinder maintenance or preparation activities are expected to be negligible. Therefore, no impacts were estimated for the noninvolved workers and the off-site general public.

Because of the small airborne release rates of depleted uranium during normal operations, potential radiation exposures of the noninvolved workers would be very small regardless of where the conversion facility was located within the Paducah site. The radiation dose incurred by the MEI was modeled to be less than 1.0×10^{-5} mrem/yr. This small radiation dose would correspond to potential excess latent cancer risks of less than 5×10^{-12} per year (1 chance in 200 billion of developing 1 LCF per year). For comparison, the dose limit set for airborne releases from operations of DOE facilities is 10 mrem/yr (40 CFR 61).

Radiation exposures of the off-site public also would be very small regardless of the location of the conversion facility. The MEI dose was modeled to be less than 3.9×10^{-5} mrem/yr. This dose is insignificant compared with the radiation dose limits of 100 mrem/yr (DOE 1990) from all pathways and 10 mrem/yr (40 CFR Part 61) from airborne pathways set to protect the general public from operations of DOE facilities. The corresponding latent cancer risk would be less than 2×10^{-11} per year (1 chance in 50 billion of developing 1 LCF per year). Because of no waterborne discharge of uranium (UDS 2003b), radiation exposure to the off-site public from using surface water near the facility would be negligible.

5.2.2.1.2 Chemical Impacts. Potential chemical impacts to human health from normal operations at the conversion facility would result primarily from exposure to trace amounts of the insoluble uranium compound U_3O_8 and to HF released from the process exhaust stack. Risks from normal operations were quantified on the basis of calculated hazard indices. General information concerning the chemical impact analysis methodology is provided in Chapter 4.

The hazard indices were calculated on the basis of air dispersion modeling, which identified the locations of maximum ground-level concentrations of uranium compounds and HF emitted from the conversion facility. Since the maximum concentration locations were used for modeling both noninvolved worker and general public exposures, the impacts would be the same for the three alternative locations assessed.

Conversion to U_3O_8 would result in very low levels of exposure to hazardous chemicals. No adverse health effects to noninvolved workers or the general public are expected during normal operations. Human health impacts resulting from exposure to hazardous chemicals during normal operations of the conversion facilities are estimated as hazard indices of 1.3×10^{-6} and 1.4×10^{-4} for the noninvolved worker and general public MEIs, respectively. The hazard indices for the conversion process would be at least four orders of magnitude lower than the hazard index of 1, which is the level at which adverse health effects might be expected to occur in some exposed individuals.

Impacts to involved workers from exposure to chemicals during normal operations are not expected. The workplace would be monitored to ensure that airborne chemical concentrations were within applicable health standards that are protective of human health and safety. If planned work activities were likely to expose involved workers to chemicals, workers would be provided with appropriate protective equipment, as necessary.

5.2.2.2 Human Health and Safety — Facility Accidents

A range of accidents covering the spectrum from high-frequency/low-consequence events to low-frequency/high-consequence accidents was considered for DUF_6 conversion operations. The accident scenarios considered such events as releases due to cylinder damage, fires, plane crashes, equipment leaks and ruptures, hydrogen explosions, earthquakes, and tornadoes. The accident scenarios considered in the assessment were those identified in the DUF_6 PEIS (DOE 1999a); the scenarios were modified to take into account the specific conversion technology and facility design proposed by UDS (UDS 2003b; Folga 2003). A list of bounding radiological and chemical accidents — that is, those accidents expected to result in the highest consequences in each frequency category should the accident occur — for the UDS conversion facility is provided in UDS (2003b). The bounding accident scenarios and their estimated consequences are discussed below for both radiological and chemical impacts.

5.2.2.2.1 Radiological Impacts. Potential radiation doses from accidents were estimated for noninvolved workers at the Paducah site and members of the public within a 50-mi (80-km) radius of the site for both MEIs and the collective populations. Impacts to involved workers under accident conditions would likely be dominated by physical forces from the accident itself; thus quantitative dose/effect estimates would not be meaningful. For these reasons, the impacts to involved workers during accidents are not quantified in this EIS. However, it is recognized that injuries and fatalities among involved workers would be possible if an accident occurred.

Table 5.2-8 lists the bounding accidents in each frequency category (i.e., the accidents that were found to have the highest consequences) for radiological impacts. The estimated radiation doses to members of the public and noninvolved workers (both MEIs and collective populations) for these accidents are presented in Table 5.2-9. Table 5.2-10 gives the corresponding risks of LCFs associated with the estimated doses for these accidents. The doses and risks are presented as ranges (minimum and maximum) because two different atmospheric conditions were considered for each accident. The estimated doses and LCFs were calculated on the basis of the assumption that the accidents would occur, without taking into account the probability of the accident's occurring. The probability of occurrence for each accident is indicated by the frequency category to which it is assigned. For example, accidents in the extremely unlikely category have an estimated probability of occurrence of between 1 in 10,000 and 1 in 1 million per year.

The accident assessment took into account the three alternative locations within the Paducah site. Because of the close proximity of the alternative locations to the site boundary and the uncertainty associated with both the wind direction at the time of the accident and the exact location of the release point, it was conservatively assumed that both the noninvolved worker MEI and the general public MEI would be located 328 ft (100 m) from accidents with a ground-level release. For accidents with the potential for plume rise due to a fire or for releases from a stack, both the worker and public MEIs were assumed to be located at the point of maximum ground-level concentrations of the released contaminants. As discussed in Appendix F, the noninvolved worker MEI was assumed to be exposed to the passing plume for

TABLE 5.2-8 Bounding Radiological Accidents Considered for Conversion Operations at the Paducah Site[a]

Accident Scenario	Accident Description	Chemical Form	Amount (lb)	Duration (min)	Release Level[b]
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft (0.30-m) hole results during handling, with solid UF_6 forming a 4-ft^2 (0.37-m^2) area on the dry ground.	UF_6	24	60 (continuous)	Ground
U_3O_8 drum spill	A single U_3O_8 drum is damaged by a forklift and spills its contents onto the ground outside the storage facility.	U_3O_8	2.4	30	Ground
Extremely Unlikely Accidents (frequency: 1 time in 10,000 years to 1 time in 1 million years)					
Earthquake	The U_3O_8 storage building is damaged during a design-basis earthquake, and 10% of the containers are breached.	U_3O_8	180	30	Stack
Rupture of cylinders – fire	Several cylinders hydraulically rupture during a fire.	UF_6	0 11,500 8,930 3,580	0–12 12 12–30 30–121	Ground
Tornado	A windblown missile from a design-basis tornado pierces a single U_3O_8 container in the storage building.	U_3O_8	1,200	0.5	Ground

[a] The accident assessment considered a spectrum of accidents in four categories, likely, unlikely, extremely unlikely, and incredible. Potential accidents in the unlikely and incredible frequency categories would not result in radiological releases, but they are considered in the chemical assessment.

[b] Ground-level releases were assumed to occur outdoors on concrete pads in the cylinder storage yards. To prevent contaminant migration, cleanup of residuals was assumed to begin immediately after the release was stopped.

2 hours after the accident, after which time he or she would be evacuated; the public MEI was assumed to remain indefinitely in the path of the passing plume and consume contaminated food grown on site.

The estimated doses and risks to the noninvolved worker and public MEIs are presented in Tables 5.2-9 and 5.2-10. The estimated impacts to the noninvolved worker MEI and public MEI are similar because 99% of the dose is due to the inhalation pathway within the first 2 hours after the accident.

TABLE 5.2-9 Estimated Radiological Doses per Accident Occurrence during Conversion at the Paducah Site[a]

		Maximum Dose				Minimum Dose			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Conversion Product/Accident[b]	Frequency Category[c]	MEI (rem)	Population[d] (person-rem)	MEI (rem)	Population (person-rem)	MEI (rem)	Population[d] (person-rem)	MEI (rem)	Population (person-rem)
Corroded cylinder spill, dry conditions	L	7.8×10^{-2}	1.1/2.4/0.6	7.8×10^{-2}	2.4×10^{-1}	3.3×10^{-3}	$(4.7/9.9/2.8) \times 10^{-2}$	3.3×10^{-3}	2.5×10^{-3}
Failure of U_3O_8 container while in transit	L	5.3×10^{-1}	7.1/17/4.0	5.3×10^{-1}	1.0	2.2×10^{-2}	$(3.2/6.6/1.9) \times 10^{-1}$	2.3×10^{-2}	1.7×10^{-1}
Earthquake	EU	40	$(5.3/12.7/3.0) \times 10^{2}$	40	73	1.7	$(2.4/5.0/1.4) \times 10^{-1}$	1.7	13
Rupture of cylinders – fire	EU	2.0×10^{-2}	9.5/6.8/8.0	2.0×10^{-2}	21	3.7×10^{-3}	$(9.6/6.7/11) \times 10^{-1}$	3.7×10^{-3}	1.2
Tornado[e]	EU	7.5	110/230/64	7.5	34	7.5	110/230/64	7.5	34

[a] Maximum and minimum doses reflect differences in meteorological conditions at the time of the accident. In general, maximum doses would occur under meteorological conditions of F stability with a 1-m/s wind (2-mph) speed; minimum doses would occur under D stability with a 4-m/s (9-mph) wind speed.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest dose to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} to 10^{-6}/yr).

[d] For the noninvolved worker population dose, three estimates are provided, corresponding to Locations A, B, and C within the Paducah site.

[e] Meteorological conditions analyzed for the tornado were D stability with a 20-m/s (45-mph) wind speed.

TABLE 5.2-10 Estimated Radiological Health Risks per Accident Occurrence during Conversion at the Paducah Site

		Maximum Risk (LCFs)[a]				Minimum Risk (LCFs)[a]			
		Noninvolved Workers		General Public		Noninvolved Workers		General Public	
Conversion Product/Accident[b]	Frequency Category[c]	MEI	Population[d]	MEI	Population	MEI	Population[d]	MEI	Population
Corroded cylinder spill, dry conditions	L	3×10^{-5}	$(0.4/1/0.2) \times 10^{-3}$	3×10^{-5}	3×10^{-5}	1×10^{-6}	$2/5/1 \times 10^{-5}$	1×10^{-6}	1×10^{-5}
U_3O_8 drum spill	L	2×10^{-4}	$(3/7/2) \times 10^{-3}$	3×10^{-4}	5×10^{-4}	9×10^{-6}	$2/3/0.9 \times 10^{-4}$	1×10^{-5}	8×10^{-5}
Earthquake	EU	2×10^{-2}	$(2/5/1) \times 10^{-1}$	2×10^{-2}	4×10^{-2}	7×10^{-4}	$1/2/0.7 \times 10^{-3}$	8×10^{-4}	6×10^{-3}
Rupture of cylinders – fire	EU	8×10^{-6}	$(4/3/3) \times 10^{-3}$	8×10^{-6}	1×10^{-2}	1×10^{-6}	$5/3/6 \times 10^{-4}$	1×10^{-6}	5×10^{-4}
Tornado[e]	EU	3×10^{-3}	$(5/10/3) \times 10^{-2}$	4×10^{-3}	2×10^{-2}	3×10^{-3}	$5/10/3 \times 10^{-2}$	4×10^{-3}	2×10^{-2}

[a] Maximum and minimum risks reflect differences in meteorological conditions at the time of the accident. In general, maximum risks would occur under meteorological conditions of F stability with a 1-m/s (2-mph) wind speed; minimum risks would occur under D stability with a 4-m/s (9-mph) wind speed. Values shown are the consequences if the accident did occur. The risk of an accident is the consequence (LCFs) times the estimated frequency times 25 years of operations.

[b] The bounding accident chosen to represent each frequency category is the one that would result in the highest risks to the general public MEI. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category. Absence of an accident in a certain frequency category indicates that the accident would not result in a release of radioactive material.

[c] Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations ($10^{-4} – 10^{-6}$/yr).

[d] For the noninvolved worker population dose, three estimates are provided, corresponding to Locations A, B, and C within the Paducah site.

[e] Meteorological conditions analyzed for the tornado were D stability with a 20-m/s (45-mph) wind speed.

For the off-site public, the location of the conversion facility within the Paducah site would have very little impact on collective exposures because the area considered (a circle with a radius of 80 km [50 mi]) would be so much larger than the area of the Paducah site. The population dose estimates are based on population distributions from the 2000 census. The collective dose to noninvolved workers, however, would depend on the location of the conversion facility with respect to other buildings within the site. Therefore, for the noninvolved worker population, three estimates are provided in Tables 5.2-9 and 5.2-10, corresponding to Locations A, B, and C within the site.

The postulated accident estimated to have the largest consequence is the extremely unlikely accident caused by an earthquake involving the conversion facility. In this scenario, it is assumed that the U_3O_8 storage building would be damaged during the earthquake and that 10% of the stored containers would be breached. Under conservative meteorological conditions (F stability class with a 1-m/s [2 mph] wind speed) expected to result in the highest possible exposures, it is estimated that the dose to the MEI member of the public and noninvolved worker from this accident would be approximately 40 rem if it is assumed that the product storage building contained 6 month's worth of production. The RFP for conversion services required the bidders to provide enough capacity to be able to store up to 6 month's worth of inventory on site. The estimated MEI doses are well below levels expected to cause immediate fatalities from radiation exposure (approximately 450 rem) and would result in a lifetime increase in the probability of developing an LCF of about 0.02 (about 1 chance in 50) in the public MEI and about 0.02 (1 chance in 50) in the worker MEI.

It is estimated that the collective doses from the U_3O_8 storage building earthquake accident would be 300 to 1,270 person-rem to the worker population and 73 person-rem to the off-site general population. These collective doses would result in less than 1 additional LCF in the worker population (0.5 LCF) and in the general population (0.04 LCF).

The accident scenario with the second-highest impacts was the extremely unlikely scenario caused by a tornado strike. In this scenario, it is assumed that a windblown missile from a tornado would pierce a single U_3O_8 container in storage. In this hypothetical accident, and if bulk bags were being used to transport and dispose of the U_3O_8 product, approximately 1,200 lb (550 kg) of U_3O_8 could be released at ground level. Under conservative meteorological conditions, it is estimated that the dose to the MEI and noninvolved worker would be 7.5 rem. The collective doses would be up to 230 person-rem to the worker population and up to 35 person-rem to the general population. If the emptied cylinders were used rather than the bulk bags as U_3O_8 containers, the resulting doses would be approximately half of the above results.

To account for the possible TRU and Tc contamination in some of the cylinders, a ratio of the dose from the TRU and Tc radionuclides at bounding maximum concentrations to the dose from the depleted uranium was calculated (see Appendix B for details). For accidents involving full DUF_6 cylinders, the relative dose contribution from TRU and Tc was found to be less than 0.02% of the dose from the depleted uranium. This approach is conservative because only a fraction of the cylinders in the inventory are contaminated with TRU, and because it is expected that the concentration in any one cylinder would be less than the bounding concentrations assumed in the analysis.

The following conclusions may be drawn from the radiological health impact results:

- No cancer fatalities are predicted for any of the accidents.

- The maximum radiological dose to the noninvolved worker and general public MEIs (assuming that an accident occurred) would be about 7.5 to 40 rem, depending on the quantity of product stored on site at the time of the accident. This dose could thus be greater than the 25-rem total effective dose equivalent established by DOE as a guideline for assessing the adequacy of protection of public health and safety from potential accidents (DOE 2000c). Therefore, more detailed analysis during facility design and siting may be necessary.

- The overall radiological risk to noninvolved worker and general public MEI receptors (estimated by multiplying the risk per occurrence [Table 5.2-10] by the annual probability of occurrence by the number of years of operations) would be less than 1 for all of the conversion facility accidents.

- At most, there would be a factor of 5 difference in noninvolved worker population impacts among the three locations. Location C would have the lowest impact for the earthquake bounding scenario. Location B would have the highest impact for this scenario.

5.2.2.2.2 Chemical Impacts. This section presents the results for chemical health impacts for the highest-consequence accident in each frequency category for conversion operations at the Paducah site. The estimated numbers of adverse and irreversible adverse effects among noninvolved workers and the general public were calculated separately for each of the three alternative locations within the site by using 2000 census data for the off-site population. The methodology and assumptions used in the calculations are summarized in Appendix F, Section F.4.

The bounding conversion facility chemical accidents are listed in Table 5.2-11 and cover events that could occur during conversion. Note that an anhydrous NH_3 tank rupture is one of the bounding chemical accidents and the accident expected to cause the greatest impacts. NH_3 is used to produce hydrogen required for the conversion process. Although the use of NH_3 for hydrogen production is part of the UDS facility design, the use of natural gas for hydrogen production, which would eliminate the need for NH_3, is also possible.

The consequences from accidental chemical releases derived from the accident consequence modeling for conversion are presented in Tables 5.2-12 and 5.2-13. The results are presented as the number of people with the potential for (1) adverse effects and (2) irreversible adverse effects. Within each frequency category, the tables present the results for the accident that would affect the largest number of people (total of workers and off-site population). The numbers of noninvolved workers and members of the off-site public represent the impacts if the associated accident occurred. The accident scenarios given in Tables 5.2-12 and 5.2-13 are not

TABLE 5.2-11 Bounding Chemical Accidents during Conversion Operations at the Paducah Site

Frequency Category/ Accident Scenario	Accident Description	Chemical Form of Release	Release Amount (lb)	Release Duration (min)	Release Level/ Medium
Likely Accidents (frequency: 1 or more times in 100 years)					
Corroded cylinder spill, dry conditions	A 1-ft (0.30-m) hole results during handling, with solid UF_6 forming a 4-ft^2 (0.37-m^2) area on the dry ground.	UF_6	24	60	Ground/ air
Unlikely Accidents (frequency: 1 in 100 years to 1 in 10,000 years)					
Corroded cylinder spill, wet conditions – rain	A 1-ft (0.30-m) hole results during handling, with solid UF_6 forming a 4-ft^2 (0.37-m^2) area on the wet ground.	HF	96	60	Ground/ air
Aqueous HF pipe rupture	An earthquake ruptures an aboveground pipeline transporting aqueous HF, releasing it to the ground.	HF	910[a]	10	Ground/ air-soil
Anhydrous NH_3 line leak	An NH_3 fill line is momentarily disconnected, and NH_3 is released at grade.	NH_3	255	1	Ground/ air
Extremely Unlikely Accidents (frequency: 1 in 10,000 years to 1 in 1 million years)					
Corroded cylinder spill, wet conditions – water pool	A 1-ft (0.30-m) hole results during handling, with solid UF_6 forming a 4-ft^2 (0.37-m^2) area into a 0.25-in. (0.64-cm)-deep water pool.	HF	147	60	Ground/ air
Rupture of cylinders – fire	Several cylinders hydraulically rupture during a fire.	UF_6	0 11,500 8,930 3,580	0 to 12 12 12 to 30 30 to 121	Ground/ air
Incredible Accidents (frequency: less than 1 in 1 million years)					
Aqueous HF (70%) tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled HF storage tank.	HF	F1: 8,710[b] D4: 25,680[b]	120	Ground/ air
Anhydrous NH_3 tank rupture	Large seismic or beyond-design-basis event causes rupture of a filled NH_3 storage tank.	NH_3	29,500	20	Ground/ air

[a] The estimate assumes that 10% of the spill evaporates, with the remainder absorbed into the soil. It should be noted that the soil/groundwater assessment conservatively assumes that 100% of the spill is absorbed into the soil.

[b] The two different atmospheric conditions considered would cause different amounts to be released. These release amounts were computed on the basis of evaporation rates estimated by assuming 77°F (25°C; F-1 conditions) and 95°F (35°C; D-4 conditions).

TABLE 5.2-12 Consequences of Chemical Accidents during Conversion at the Paducah Site: Number of Persons with the Potential for Adverse Effects[a]

		Maximum No. of Persons per Location[d]												Minimum No. of Persons per Location[d]											
		Noninvolved Worker						General Public						Noninvolved Workers						General Public					
		MEI[e]			No. Affected			MEI[e]			No. Affected			MEI[e]			No. Affected			MEI[e]			No. Affected		
Accident[b]	Freq. Cat.[c]	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Corroded cylinder spill, dry conditions	L	Yes	Yes	Yes	13	110	71	No	No	No	0	0	0	Yes[f]	Yes[f]	Yes[f]	0	0	0	No	No	No	0	0	0
Corroded cylinder spill, wet conditions – rain	U	Yes	Yes	Yes	730	590	670	Yes	Yes	Yes	18	13	11	Yes	Yes	Yes	0	22	0	No	No	No	0	0	0
Rupture of cylinders – fire	EU	Yes	Yes	Yes	800	440	1,000	Yes	Yes	Yes	1,300	1,400	3,100	Yes	Yes	Yes	260	120	270	Yes	Yes	Yes	7	4	5
HF tank rupture	I	Yes	Yes	Yes	1,400	1,100	1,100	Yes	Yes	Yes	3,800	3,500	4,400	Yes	Yes	Yes	1,080	930	900	Yes	Yes	Yes	42	29	24
NH_3 tank rupture	I	Yes	Yes	Yes	1,600	1,400	1,600	Yes	Yes	Yes	4,800	4,900	6,700	Yes	Yes	Yes	1,100	1,100	1,400	Yes	Yes	Yes	26	14	17

[a] The values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency, times 25 years of operations. The estimated frequencies are as follows: L = likely, 0.1; U = unlikely, 0.001; EU = extremely unlikely, 0.00001; I = incredible, 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations (> 10^{-2}/yr); U = unlikely, estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} to 10^{-4}/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} to 10^{-6}/yr); I = incredible, estimated to occur less than one time in 1 million years of facility operations (< 10^{-6}/yr).

[d] Maximum and minimum values reflect differences in assumed meteorological conditions at the time of the accident. In general, the maximum risks would occur under meteorological conditions of F stability with a 1-m/s (2-mph) wind speed; the minimum risks would occur under D stability with a 4-m/s (9-mph) wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m (328 ft) from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

TABLE 5.2-13 Consequences of Chemical Accidents during Conversion at the Paducah Site: Number of Persons with the Potential for Irreversible Adverse Effects[a]

		Maximum No. of Persons per Location[d]												Minimum No. of Persons per Location[d]											
		Noninvolved Worker						General Public						Noninvolved Workers						General Public					
		MEI[e]			No. Affected			MEI[e]			No. Affected			MEI[e]			No. Affected			MEI[e]			No. Affected		
Conversion Product/Accident[b]	Freq. Cat.[c]	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A	B	C
Conversion to U_3O_8																									
Corroded cylinder spill, dry conditions	L	Yes[f]	Yes	Yes	0	9	0	No	No	No	0	0	0	No	Yes	Yes	0	0	0	No	No	No	0	0	0
Corroded cylinder spill, wet conditions – rain	U	Yes	Yes	Yes	130	310	71	No	No	No	0	0	0	Yes	Yes	Yes	0	7	0	No	No	No	0	0	0
Corroded cylinder spill, wet conditions – water pool	EU	Yes	Yes	Yes	400	410	71	Yes	Yes	Yes	0	0	0	Yes	Yes	Yes	0	19	0	No	No	No	0	0	0
NH_3 tank rupture[g]	I	Yes	Yes	Yes	1,600	1,400	1,600	Yes	Yes	Yes	370	320	220	Yes	Yes	Yes	600	700	130	Yes	Yes	Yes	2	0	1

[a] The values shown are the consequences if the accident did occur. The risk of an accident is the consequence (number of persons) times the estimated frequency, times 25 years of operations. The estimated frequencies are as follows: L = likely, 0.1; U = unlikely, 0.001; EU = extremely unlikely, 0.00001; I = incredible, 0.000001.

[b] The bounding accident chosen to represent each frequency category is the one in which the largest number of people (workers plus off-site population) would be affected. Health impacts in that row represent that accident only and not the range of impacts among accidents in that category.

[c] Accident frequencies: L = likely, estimated to occur one or more times in 100 years of facility operations ($> 10^{-2}$/yr); U = unlikely, estimated to occur between once in 100 years and once in 10,000 years of facility operations (10^{-2} to 10^{-4}/yr); EU = extremely unlikely, estimated to occur between once in 10,000 years and once in 1 million years of facility operations (10^{-4} to 10^{-6}/yr); I = incredible, estimated to occur less than one time in 1 million years of facility operations ($< 10^{-6}$/yr).

[d] Maximum and minimum values reflect differences in assumed meteorological conditions at the time of the accident. In general, the maximum risks would occur under meteorological conditions of F stability with a 1-m/s (2-mph) wind speed; the minimum risks would occur under D stability with a 4-m/s (9-mph) wind speed.

[e] At the MEI location, the determination is either "Yes" or "No" for potential adverse effects to an individual.

[f] MEI locations were evaluated at 100 m (328 ft) from ground-level releases for workers and at the location of highest off-site concentration for members of the general public; the population risks are 0 because the worker and general public population distributions for the site were used, which did not show receptors at the MEI locations.

[g] Under D-stability, 4-m/s (9-mph) meteorological conditions (minimum no. of persons affected), an aqueous HF tank rupture would have higher consequences to noninvolved workers than would the NH_3 tank rupture, resulting in about 200 to 300 more irreversible adverse effects at Locations A and B, respectively. However, under F-stability, 1-m/s (2-mph) meteorological conditions (maximum number of persons affected), the NH_3 tank rupture would have the maximum consequences to noninvolved workers and the general public.

identical because an accident with the largest impacts for adverse effects might not lead to the largest impacts for irreversible adverse effects. The impacts may be summarized as follows:

- The largest impacts would be caused by the following accident scenarios: an HF storage tank rupture; a corroded cylinder spill under wet conditions (i.e., rain and formation of a water pool); an NH_3 tank rupture; and rupture of several cylinders in a fire. Accidents involving stack emissions would have smaller impacts than would accidents involving releases at ground level because of the relatively larger dilution rates and smaller release rates (due to filtration) involved with the stack emissions.

- If the accidents identified in Tables 5.2-12 and 5.2-13 did occur, the number of persons in the off-site population with the potential for adverse effects would range from 0 to around 6,700 (maximum corresponding to a release from an NH_3 pressurized tank rupture at Location C), and the number of off-site persons with the potential for irreversible adverse effects would range from 0 to around 370 (maximum corresponding to a release from an NH_3 pressurized tank rupture at Location A).

- If the accidents identified in Tables 5.2-12 and 5.2-13 did occur, the number of noninvolved workers with the potential for adverse and irreversible adverse effects would be about the same, ranging from 0 to around 1,600 (maximum corresponding to an NH_3 pressurized tank rupture at Locations A and C). Although the calculated hazard distances for adverse effects are over twice the hazard distances for irreversible affects (i.e., 7 mi [11 km] versus 2 mi [4 km]), the hazard zones for each of the health effect levels (Emergency Response Planning Guide [ERPG]-1 and ERPG-2) cover approximately the same noninvolved worker areas near the release locations for Locations A, B, or C.

- For over half of the bounding accident scenarios (NH_3 pressurized tank rupture, HF tank rupture, and rupture of cylinders in a fire), the greatest number of adverse effects among the off-site public and noninvolved workers would occur at Location C. The NH_3 pressurized tank rupture and the rupture of cylinders at Location C would result in the greatest number of affected noninvolved workers, while the HF tank rupture and corroded cylinder spill in wet conditions at Location A would result in the greatest number of affected noninvolved workers. For the cylinder spill scenario under either dry or wet conditions, the maximum number of adverse effects would occur at Locations A or B.

- The greatest number of irreversible adverse effects (associated with an NH_3 pressurized tank rupture) would occur at Location A for the off-site public and at Locations A or C for the noninvolved workers. For corroded cylinder spill scenarios, the greatest number of irreversible adverse effects for noninvolved workers would occur at Location B.

- For the most severe accidents in each frequency category, the noninvolved worker MEI and the public MEI would have the potential for both adverse effects and irreversible adverse effects. The likely accidents for each conversion option (frequency of more than 1 chance in 100 per year) would result in no potential adverse or irreversible adverse effects for the general public. The generally reduced impacts to the public compared with the noninvolved worker would be related to the dispersion or dilution of the chemical plume with downwind distance (except for a UF_6 cylinder rupture in a fire). The buoyancy effect of the plume in a fire tends to move the location of maximum impacts away from the accident and closer to the higher population areas.

- The maximum risk was computed as the product of the consequence (number of people) times the frequency of occurrence (occurrences per year) times the number of years of operations (25 years). These risk values presented below are conservative because the numbers of people affected were based on the following assumptions: (1) occurrence of very low wind speed and moderately stable meteorological conditions that would result in the maximum reasonably foreseeable plume size (i.e., F stability and a 1-m/s [2-mph] wind speed), and (2) steady or nonmeandering wind direction, lasting up to 3 hours and blowing toward locations that would lead to the maximum number of individuals exposed for noninvolved workers or for the general population. The results indicate that the maximum risk values would be less than 1 for all accidents except the following:

  – *Potential Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely), workers

  Assuming the accident occurred once every 10 years (frequency = 0.1 per year), about 33 workers would potentially experience an adverse effect over the 25-year operational period at alternative Location A, about 280 at alternative Location B, and about 180 at alternative Location C.

  Corroded cylinder spill, wet conditions – rain (U, unlikely), workers

  Assuming the accident occurred once every 1,000 years (frequency = 0.001 per year), about 18 workers would potentially experience an adverse effect over the 25-year operational period at alternative Location A, about 15 at alternative Location B, and about 17 at alternative Location C.

  – *Potential Irreversible Adverse Effects:*

  Corroded cylinder spill, dry conditions (L, likely), workers

  Assuming the accident occurred once every 10 years (frequency = 0.1 per year), the expected numbers of workers who would potentially experience an irreversible adverse effect over the 25-year operational period at alternative Locations A, B, and C would be 0, 23, and 0, respectively.

Corroded cylinder spill, wet conditions – rain (U, unlikely), workers
Assuming the accident occurred once every 1,000 years (frequency = 0.001 per year), about 3 workers would potentially experience an irreversible adverse effect over the 25-year operational period at alternative Location A, about 8 at alternative Location B, and about 2 at alternative Location C.

The number of fatalities that could potentially be associated with the estimated irreversible adverse effects was also calculated. Previous analyses indicated that exposure to HF and uranium compounds, if sufficiently high, could result in death to 1% or less of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Similarly, it was estimated that exposure to NH_3 could result in death to about 2% of the persons experiencing irreversible adverse effects (Policastro et al. 1997). Therefore, if the corroded cylinder spill, wet conditions – rain accident occurred (Table 5.2-13), about 1 fatality might be expected among the noninvolved workers at alternative Locations A and C; about 3 fatalities might be expected if the accident occurred at alternative Location B. However, this accident is classified as an unlikely accident, meaning that it is estimated to occur between once in 100 years and once in 10,000 years of facility operation. Assuming that it would occur once every 1,000 years, the risk of fatalities among the noninvolved workers from this accident over the 25-year operational period would be less than 1 ($1 \times 0.0001 \times 25 = \approx 0.03$ at Locations A and C, and $3 \times 0.001 \times 25 = \approx 0.08$ at Location B). (See Section 4.3 for discussion on interpretation of risk numbers that are less than 1.)

Similarly, if the higher-consequence accident in the extremely unlikely frequency category (corroded cylinder spill, wet conditions – water pool) in Table 5.2-13 occurred, approximately 4 fatalities might be expected among the noninvolved workers at alternative Locations A and B, and about 1 fatality at alternative Location C. However, because of the low frequency of this accident, the risk of a fatality over the lifetime of the conversion facility would be about 0.001 at Locations A and C and about 0.0003 at Location B, assuming a frequency of 0.00001 per year.

For the NH_3 tank rupture accident, which belongs to the incredible frequency category (frequency of less than 0.000001 per year), the expected numbers of fatalities among the noninvolved workers would be about 32, 28, and 32 for Locations A, B, and C, respectively, if the accident occurred. However, the risk of a fatality would be much less than 1 at any of the locations (about 0.0004, assuming a frequency of 5×10^{-7} per year) over the facility lifetime. Among the general public, about 7, 6, or 4 fatalities might be expected if the same accident occurred at Locations A, B, or C, respectively. However, because of the low frequency of the accident, the risk of fatalities would be much less than 1 (about 0.0001).

Even though the risks are relatively low, the consequences for a few of the accidents are considered to be high. These high-consequence accidents are generally associated with the storage of anhydrous NH_3 and aqueous HF on site. The consequences can be reduced or mitigated through design (e.g., by limiting their capacity), operational procedures (e.g., by controlling accessibility to the tanks), and emergency response actions (e.g., by sheltering, evacuation, and interdiction of contaminated food materials following an accident.) As an example, UDS is proposing to reduce the size of the anhydrous NH_3 storage tanks from 9,200 gal to 3,300 gal (34,826 L to 12,492 L). This change would reduce the consequences of an ammonia release accident. However, to conservatively estimate the consequences of an anhydrous ammonia tank rupture and preserve process flexibility, this analysis retained the assumption of a 9,200-gal (34,826-L) tank size.

5.2.2.2.3 Physical Hazards. The risk of on-the-job fatalities and injuries to conversion facility workers was calculated by using industry-specific statistics from the BLS, as reported by the National Safety Council (2002). Annual fatality and injury rates from the BLS manufacturing industry division were used for the 25-year operations phase, assuming no ETTP cylinders are processed. Operation of the conversion facility is estimated to require approximately 175 FTEs per year. No on-the-job fatalities are predicted during the conversion facility operational phase. It is estimated, however, that about 197 injuries would occur (Table 5.2-1).

5.2.2.3 Air Quality and Noise

5.2.2.3.1 Air Quality Impacts. Three alternative locations (Locations A, B, and C) were considered for air quality impacts. Detailed information on facility boundaries and the orientations and locations of buildings and stacks is currently available for preferred Location A only. For Locations B and C, the layout of the facility for Location A was assumed to be placed in the middle of the other two locations.

At the conversion facility, air pollutants would be emitted from four point sources: the boiler stack, backup generator stack, conversion building stack, and HF processing building stack. UDS is proposing to use electrical heating in the conversion facility, but it is evaluating other options. If natural gas was chosen, furnaces or boilers could be used. To assess bounding air quality impacts, a boiler option was analyzed because it would result in more emissions than furnaces or electric heat. The boilers could be used to generate process steam and building heat, and a backup generator would be used to provide emergency electricity. Primary emission sources for criteria pollutants and VOCs would be the boiler and emergency generator. The conversion building stack would release uranium, fluoride, criteria pollutants, and VOCs in minute amounts, while the HF processing building stack would release fluorides into the atmosphere. Although nitrogen would be used as a purge gas in the process, its use would not generate additional NO_X emissions, because of the absence of oxygen in contact with the nitrogen stream at high temperatures. Annual total stack emission rates during operations are given in the Engineering Support Document (Folga 2003), and these emission rates are presented in Table 5.2-14. Other sources during operations would include vehicular traffic to and from the facility, associated with cylinder transfer, commuting, and material delivery. Parking lots and access roads to the facility would be paved with asphalt or concrete to minimize fugitive dust emissions. In addition, fugitive emissions would include those from storage tanks, silos, cooling towers, etc., but in negligible amounts.

TABLE 5.2-14 Annual Point Source Emissions of Criteria Pollutants, Volatile Organic Compounds, Uranium, and Fluoride from Operation of the Conversion Facility at the Paducah Site

	Emission Rate[a]			
Pollutant	Boiler[b]	Backup Generator	Conversion Building Stack	HF Processing Building Stack
SO_2	0.01	0.17	1.3×10^{-3}	–[c]
NO_x	2.09	1.20	3.4×10^{-2}	–
CO	1.25	0.17	5.3×10^{-2}	–
VOC	0.08	0.17	1.5×10^{-2}	–
PM_{10}[d]	0.11	0.07	9.0×10^{-3}	–
Uranium	–	–	< 0.25 g/yr	–
Fluoride	–	–	< 0.05 ppm[e]	< 0.05 ppm[f]

[a] Tons/yr unless otherwise noted.

[b] Boiler emissions were estimated on the basis of annual natural gas usage given in Table 5.2-19.

[c] A dash indicates no or negligible emissions.

[d] $PM_{2.5}$ emissions are assumed to be the same as PM_{10} emissions.

[e] Annual emission is about 1.1 kg (2.4 lb) as HF.

[f] Annual emission is about 70.5 kg (155 lb) as HF.

The modeling results for concentration increments of SO_2, NO_2, CO, PM_{10}, $PM_{2.5}$, and HF due to emissions from operations of the proposed facility are summarized in Table 5.2-15. The results are maximum modeled concentrations at or beyond the conversion facility boundary. The total concentrations (modeled concentration increments plus background concentrations) are also presented in this table for comparison with applicable NAAQS and SAAQS.

Because of the low emissions during facility operations, all air pollutant concentration increments during operations would be well below applicable standards. As shown in Table 5.2-15, the estimated maximum concentration increments due to operation of the proposed facility would amount to about 16% of the applicable standard for 24-hour average SO_2. This concentration increment is primarily due to a backup generator, which is located next to the conversion building and the site boundaries and within the building cavity/wake region. However, the generator would be operating on an intermittent basis, and thus air quality impacts would be limited to the period of its operation. The total concentrations except for annual-average $PM_{2.5}$, would be well below their applicable standards. The total annual average $PM_{2.5}$ concentration is predicted to be about 99% of its standard, but its background concentration would approach its standard (about 98%). As previously mentioned, the annual average $PM_{2.5}$ concentration at most statewide monitoring stations would either approach or exceed the standard.

TABLE 5.2-15 Maximum Air Quality Impacts Due to Emissions from Activities Associated with Operation of the Conversion Facility at the Paducah Site

		Concentration (µg/m^3)						
							Percent of NAAQS/SAAQS[d]	
Location	Pollutant	Averaging Time	Maximum Increment[a]	Background[b]	Total[c]	NAAQS and SAAQS	Increment	Total
A	SO_2	3 hours	178	169	347	1,300	13.7	26.7
		24 hours	57.2	86.0	143	365	15.7	39.2
		Annual	0.2	13.3	13.5	80	0.2	16.8
	NO_2	Annual	1.2	22.6	23.8	100	1.2	23.8
	CO	1 hour	245	6,970	7,220	40,000	0.6	18.0
		8 hours	106	3,220	3,330	10,000	1.1	33.3
	PM_{10}	24 hours	14.8	79.0	93.8	150	9.9	62.6
		Annual	0.07	25.0	25.1	50	0.1	50.1
	$PM_{2.5}$	24 hours	2.2	31.1	33.3	65	3.4	51.3
		Annual	0.07	14.7	14.8	15	0.5	98.5
	HF	12 hours	0.14	1.04	1.18	3.68	3.8	32.1
		24 hours	0.09	0.86	0.95	2.86	3.1	33.2
		1 week	0.04[e]	0.50	0.54	1.64	2.5	33.1
		1 month	0.02	0.34	0.35	0.82	1.9	42.8
		Annual	0.01	0.17	0.18	400	0.002	0.04
B	SO_2	3 hours	162	169	331	1,300	12.5	25.5
		24 hours	48.8	86	135	365	13.4	36.9
		Annual	0.1	13.3	13.4	80	0.2	16.8
	NO_2	Annual	1.0	22.6	23.6	100	1.0	23.6
	CO	1 hour	252	6,970	7,220	40,000	0.6	18.1
		8 hours	97.3	3,220	3,320	10,000	1.0	33.2
	PM_{10}	24 hours	14.9	79.0	93.9	150	9.9	62.6
		Annual	0.06	25.0	25.1	50	0.1	50.1
	$PM_{2.5}$	24 hours	1.9	31.1	33.0	65	2.9	50.8
		Annual	0.06	14.7	14.8	15	0.4	98.4
	HF	12 hours	0.07	1.04	1.12	3.68	2.0	30.3
		24 hours	0.06	0.86	0.92	2.86	2.0	32.1
		1 week	0.03[e]	0.50	0.53	1.64	1.6	32.2
		1 month	0.01	0.34	0.35	0.82	1.4	42.3
		Annual	0.007	0.17	0.17	400	0.002	0.04
C	SO_2	3 hours	86.6	169	256	1,300	6.7	19.7
		24 hours	32.4	86	118	365	8.9	32.4
		Annual	0.06	13.3	13.4	80	0.1	16.7

TABLE 5.2-15 (Cont.)

			Concentration ($\mu g/m^3$)					
							Percent of NAAQS/SAAQS[d]	
Location	Pollutant	Averaging Time	Maximum Increment[a]	Background[b]	Total[c]	NAAQS and SAAQS	Increment	Total
	NO_2	Annual	0.5	22.6	23.1	100	0.5	23.1
	CO	1 hour	206	6,970	7,180	40,000	0.5	17.9
		8 hours	54.7	3,220	3,270	10,000	0.5	32.7
	PM_{10}	24 hours	7.7	79.0	86.7	150	5.1	57.8
		Annual	0.03	25.0	25.0	50	0.1	50.1
	$PM_{2.5}$	24 hours	1.0	31.1	32.1	65	1.6	49.4
		Annual	0.03	14.7	14.7	15	0.2	98.2
	HF	12 hours	0.07	1.04	1.11	3.68	1.8	30.1
		24 hours	0.05	0.86	0.91	2.86	1.7	31.8
		1 week	0.02[e]	0.50	0.52	1.64	1.3	31.9
		1 month	0.01	0.34	0.34	0.82	1.1	42.1
		Annual	0.006	0.17	0.17	400	0.001	0.04

[a] Data represent the maximum concentration increments estimated, except that the fourth- and eighth-highest concentration increments estimated are listed for 24-hour PM_{10} and $PM_{2.5}$.

[b] See Table 3.1-3 for criteria pollutants and ANL (1991a) for highest weekly and annual HF. Background HF for other averaging times was estimated based on highest weekly and annual background concentrations.

[c] Total equals the maximum modeled concentration increment plus background concentration.

[d] The values in the next-to-last column are maximum concentration increments as a percent of NAAQS and SAAQS. The values presented in the last column are total concentration as a percent of NAAQS and SAAQS.

[e] Estimated by interpolation.

The air quality impacts would be limited to the immediate vicinity of site boundaries. For example, the maximum predicted concentration at the nearest residence on McCall Road would be less than 3% of the highest concentration. Accordingly, it is expected that potential impacts from the proposed facility operations on the air quality of nearby communities would be negligible.[4]

The maximum 3-hour, 24-hour, and annual SO_2 concentration increments predicted to result from the proposed facility operations would be about 63% of the applicable PSD increments (Table 3.1-3). The maximum predicted increments in annual-average NO_2 concentrations due to the proposed facility operations would be about 5% of the applicable PSD.

[4] Formerly, the general public had access to the existing fenced gaseous diffusion plant boundaries. However, since the September 11, 2001, terrorist attack, site access for the general public has been restricted indefinitely to the DOE property boundaries.

The 24-hour and annual PM_{10} concentration increases predicted to result from the proposed operations would be about 50% of the applicable PSD increments. As mentioned earlier, this is due to a backup generator, only when it is in operation. The predicted concentration increment at a receptor located 30 mi (50 km) from the proposed facility (the maximum distance for which the Industrial Source Complex 3 [ISC3] short-term model [EPA 1995] could reliably estimate concentrations) in the direction of the nearest Class I PSD area (Mingo National Wildlife Refuge, Missouri) would be less than 0.5% of the applicable PSD increments. Concentration increments at this refuge, which is located about 70 mi (113 km) west of Paducah, would be much lower.

Concentration increments for the two remaining criteria pollutants, Pb and O_3, were not modeled. As a direct result of the phase-out of leaded gasoline in automobiles, average Pb concentrations in urban areas throughout the country have decreased dramatically. It is expected that emissions of Pb from the proposed facility operations would be negligible and would therefore have no adverse impacts on Pb concentrations in surrounding areas. Contributions to the production of O_3, a secondary pollutant formed from complex photochemical reactions involving O_3 precursors, including NO_x and VOCs, cannot be accurately quantified. As discussed in Section 3.1.3, McCracken County, including the Paducah site, is currently in attainment for O_3 (40 CFR 81.318). The O_3 precursor emissions from the proposed facility operations would be insignificant, making up less than 0.01% and 0.08% of 1999 McCracken County emissions of NO_x and VOCs, respectively. As a consequence, the cumulative impacts of potential releases from Paducah GDP operations on regional O_3 concentrations would not be of concern.

Maximum HF air quality impacts are also listed in Table 5.2-15. The estimated maximum short-term (≤1 month) HF concentration increment and total concentration would be about 3.8% and 42.8% of the state standard, respectively, which are still well below the standards. The annual average concentration increment and total concentration would be several orders of magnitude lower than any applicable HF air quality standard.

In summary, except for annual average $PM_{2.5}$, total concentrations would be below their applicable standards. Total maximum estimated concentrations, except for annual average $PM_{2.5}$, would be less than 63% of NAAQS and SAAQS. Total maximum estimated concentrations for $PM_{2.5}$ would approach NAAQS and SAAQS; however, their concentration increments associated with site operations would account for about only 0.5% of the standards. In particular, the annual average $PM_{2.5}$ concentrations at most sitewide monitoring stations would either approach or exceed the standard.

Accidents. Among chemicals released as a result of accidents, HF would be the only one subject to an ambient air quality standard (the Commonwealth of Kentucky HF standard). Most accidental releases would occur over a short duration, about 2 hours at most. The passage time of a plume with an elevated concentration for any receptor location would be a little longer than its release duration. The HF concentration in the plume's path would exceed the 12-hour or 24-hour state ambient standard for the HF tank rupture accident scenario; however, when concentrations are averaged over a year, the annual ambient air quality standard would not be exceeded. Therefore, potential impacts of accidental releases on ambient air quality would be short-term and limited to along the plume path, and long-term impacts would be negligible.

5.2.2.3.2 Noise Impacts. Many noise sources associated with operation would be inside the buildings. The highest noise levels are expected inside the conversion facility in the area of the powder receiver vessels, with measured readings at 77 to 79 dB(A), and in the area of dry conversion, with a reading of 72 to 74 dB(A) (UDS 2003b). Ambient facility noise levels, measured in various processing areas (inside buildings) for continuous operations of a similar facility at Richland, Washington, ranged from 70 to 79 dB(A). Major outdoor noise sources associated with operation would include the cooling tower, trucks and heavy equipment for moving cylinders, and traffic moving to and from the facility, which are typical industrial noise sources. Heavy equipment and truck traffic would be intermittent; thus, noise levels would be low except when equipment was moving or operating. For noise impact analysis, a continuous noise source during operation was assumed to be 79 dB(A) at a distance of 15 m (50 ft),[5] on the basis of the highest noise level measured inside buildings at the Richland facility (UDS 2003b).

The nearest residence, located about 1.3 km (0.8 mi) southeast of Location C and just off DOE's eastern boundary on McCall Road, was selected as the receptor for the analysis of potential noise impacts. Noise levels decrease about 6 dB per doubling of distance from the point source because of the way sound spreads geometrically over increasing distance. The estimated noise level would result in about 40 dB(A) at the nearest residence. This level would be about 46 dB(A) as DNL, if 24-hour continuous operation is assumed. This level is below the EPA guideline of 55 dB(A) as DNL for residential zones (see Section 3.1.3.4), which was established to prevent interference with activity, annoyance, and hearing impairment. If other attenuation mechanisms, such as ground effects or air absorption, are considered, noise levels at the nearest residence would decrease to below background levels of about 44 to 47 dB(A) (see Section 3.1.3.4).

Most trains would blow their whistles loud enough to ensure that all motorists and pedestrians nearby would be aware of an approaching train. These excessive noises could disturb those who live or work near the train tracks. Typical noise levels of train whistles would range from 95 to 115 dB(A) at a distance of 30 m (100 ft), comparable to those of low-flying aircraft or emergency vehicle sirens (DOT 2003b). Associated with facility operations, the total number of shipments (railcars) would be less than 10,000 railcars. It would be equivalent to about two trains per week, assuming five railcars per train. Accordingly, the noise level from train operations would be high along the rail tracks and, in particular, near the crossings. However, noise impacts would be infrequent and of short duration.

In general, facility and infrequent rail traffic operations produce less noise than construction activities. For all three alternative locations, except for intermittent vehicular traffic, the noise level at the nearest residence would be comparable to the ambient background level

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5 Noise level from one of the continuous outdoor noise sources, a cooling tower, to be used at this size of a facility, would be less than 79 dB(a) at a distance of 15 m (50 ft).

discussed in Section 3.1.3.4, and it would be barely or not distinguishable from the background level, depending on the time of day. In conclusion, noise levels generated by facility operation would have negligible impacts on the residence located nearest to the proposed facility and would be well below the EPA guideline limits for residential areas.

5.2.2.4 Water and Soil

Operation of a conversion facility at Paducah would disturb land, use water, and produce liquid wastes. The following sections discuss impacts to surface water, groundwater, and soil resources during operations. Because no site-specific impacts to water and soil were identified, impacts at alternative Locations A, B, and C would be the same.

5.2.2.4.1 Surface Water. All of the water needed for a conversion facility at Paducah would be withdrawn from the Ohio River. Potable water consumption would be 3 million gal/yr (11.4 million L/yr). An additional 37 million gal/yr (140 million L/yr would be needed for nonpotable uses (e.g., cooling tower makeup). The total water needed would be about 0.00004% of the average flow in the Ohio River. Impacts of this withdrawal would be negligible.

About 4,000 to 8,000 gal/d (15,100 to 30,200 L/d) of sanitary wastewater would be produced by the conversion facility. If sanitary wastewater were released at a constant rate of 2.8 to 5.6 gal/min (11 to 22 L/min) after treatment in the wastewater treatment plant, impacts to the receiving water (Bayou Creek) would not be measurable.

There would be about 4,000 gal/d (15,000 L/min) of process wastewater produced during normal operations. This water would not contain any radionuclides. About 31,000 gal/d (117,000 L/d) (11.3 million gal/yr [42.8 million L/yr]) of wastewater would be produced by cooling tower blowdown. These wastewaters would not contain any radionuclides and could be disposed of to the existing process wastewater treatment system at Paducah, or discharged under a KPDES permit, or treated and reused at the conversion facility. Disposition of these wastewaters is under evaluation.

Accidents. An earthquake could rupture an aboveground pipeline carrying liquid HF from the conversion building to the storage building at a rate of 10 gal/min (38 L/min). For assessing potential surface water or groundwater impacts of this accident scenario, it was assumed that 100% of the HF would drain onto the ground during a 10-minute release period. Approximately 910 lb (410 kg) of liquid HF would be released. Because response and cleanup would occur within a relatively short time after the release (i.e., days or weeks), the HF would have little time to migrate into the soil. Removal of the contaminated soil would prevent any problems of contamination of either surface or groundwater resources. Therefore, there would be no impacts to surface water or groundwater from this type of accident. A similar quick response and cleanup would minimize the impacts of an HF spill to the ground during transfer to railcars.

5.2.2.4.2 Groundwater. Because all water used at the Paducah site would be obtained from the Ohio River and there would be no direct discharges to the underlying aquifers, there would be no impacts to groundwater recharge, depth, or flow direction from operation of a conversion plant at Paducah. However, the quality of groundwater beneath the selected site could be affected by infiltration of contaminated surface water from spills. Indirect contamination could result from the dissolution and mobilization of exposed chemicals by precipitation and subsequent infiltration of the contaminated runoff into the surficial aquifers. Again, following good engineering and operating practices would minimize impacts to groundwater quality.

Accidents. An earthquake could rupture an aboveground HF pipeline that would carry liquid HF from the conversion building to the storage building, or HF could be spilled during transfer to a railcar. Rapid removal of the contaminated soil would prevent any problems of contamination to underlying groundwater resources. Therefore, there would be no impacts to groundwater from these accidents.

5.2.2.4.3 Soils. Normal operations of a conversion facility at the Paducah site would have no direct impacts to soil at all three alternative locations.

Accidents. The only accidents identified that could potentially affect soil would be an HF pipeline rupture and an HF spill during transfer to railcars. Because mitigation would be rapidly initiated and because the volume of HF released would be small (910 lb [410 kg]), impacts to soil would be negligible.

5.2.2.5 Socioeconomics

The socioeconomic analysis covers the effects on population, employment, income, regional growth, housing, and community resources in the ROI around the Paducah site. Impacts from operations, which are the same for all three alternative locations, are summarized in Table 5.2-16.

The potential socioeconomic impacts from operating a conversion facility at Paducah would be relatively small. It is estimated that operational activities would create about 160 direct jobs annually, and about 170 more indirect jobs in the ROI. A conversion facility would produce approximately $13 million in personal income annually during operations.

It is estimated that about 220 people would move to the area at the beginning of operations. However, in-migration would have only a marginal effect on population growth and would require about 1% of vacant owner-occupied housing during facility operations. No significant impact on public finances would occur as a result of in-migration. Fewer than five new local public service employees would be required to maintain existing levels of service in the various local public service jurisdictions in McCracken County.

5.2.2.6 Ecology

5.2.2.6.1 Vegetation. A portion of the conversion product released from the process stack of the conversion facility would become deposited on the soils surrounding the site at Locations A, B, or C. Uptake of uranium-containing compounds can cause adverse effects to vegetation. Deposition of uranium compounds on soils, resulting from atmospheric emissions, would result in soil uranium concentrations considerably below the lowest concentration known to produce toxic effects in plants. Because there would not be a release of process effluent from the facility to surface waters, impacts to vegetation along nearby streams would not occur. Therefore, toxic effects on vegetation from uranium uptake would be expected to be negligible.

5.2.2.6.2 Wildlife. Noise generated by the operation of a conversion facility at Location A and disturbance from human presence would likely result in a minor disturbance to wildlife in the vicinity. Movement of railcars along the new rail line southwest of the facility might potentially cause the adjacent mature deciduous forest habitat to be unsuitable for some species.

During operations, ecological resources in the vicinity of the conversion facility would be exposed to atmospheric emissions from the boiler stack, cooling towers, and process stack; however, emission levels are expected to be extremely low. The highest average air concentration of uranium compounds would result in a radiation exposure to the general public (nearly 100% due to inhalation) of 3.9×10^{-5} mrem/yr, well below the DOE guideline of 100 mrem/yr. Wildlife species are less sensitive to radiation than humans. (DOE guidelines require an absorbed dose limit to terrestrial animals of less than 0.1 rad/d [DOE 2002d].) Therefore, impacts to wildlife from radiation are expected to be negligible. Toxic effect levels of chronic inhalation of uranium are many orders of magnitude greater than expected emissions from the conversion facility. Therefore, toxic effects on wildlife as a result of inhalation of uranium compounds are also expected to be negligible.

TABLE 5.2-16 Socioeconomic Impacts from Operation of the Conversion Facility at the Paducah Site

Impact Area	Operation Impacts[a]
Employment	
Direct	160
Total	330
Income (millions of 2002 $)	
Direct	5.8
Total	13.2
Population (no. of new ROI residents)	220
Housing (no. of units required)	80
Public finances (% impact on fiscal balance)	
Cities in McCracken County[b]	0.2
McCracken County	0.1
Schools in McCracken County[c]	0.2
Public service employment (no. of new employees in McCracken County)	
Police	0
Firefighters	0
General	1
Physicians	0
Teachers	1
No. of new staffed hospital beds (McCracken County)	1

[a] Impacts are shown for the first year of operations (2006).

[b] Includes impacts that would occur in the City of Paducah.

[c] Includes impacts that would occur in the McCracken County school district.

The maximum annual average air concentration of HF due to operation of a conversion facility would be 0.01 μg/m^3. Toxic effect levels of chronic inhalation of HF are many orders of magnitude greater than expected emissions. Therefore, toxic effects to wildlife from HF emissions would be expected to be negligible.

Impacts to wildlife from the operation of a conversion facility at Locations B or C would be similar to impacts at Location A. Noise and human presence would likely result in a minor disturbance to wildlife in the vicinity.

5.2.2.6.3 Wetlands. Liquid process effluents would not be discharged to surface waters during the operation of the conversion facility (Section 5.2.2.4). In addition, water level changes in the Ohio River because of water withdrawal for operations would be negligible. Regional groundwater changes due to the increase in impermeable surface related to the presence of the facility would also be negligible. Therefore, except for potential local indirect impacts near the facility, impacts to regional wetlands due to changes in groundwater or surface water levels or flow patterns would be expected to be negligible. As a result, adverse effects on wetlands or aquatic communities from effluent discharges or water use are not expected.

Storm water runoff from conversion facility parking areas and other paved surfaces might carry contaminants commonly found on these surfaces to local streams. Biota in receiving streams might be affected by these contaminants, resulting in reduced species diversity or changes in community composition. Storm water discharges from the conversion facility would be addressed under a new or existing KPDES Permit for industrial facility storm water discharge. The streams near Locations A, B, and C currently receive runoff and associated contaminants from various roadways and storage yards on the Paducah site, and their biotic communities are likely indicative of developed areas.

5.2.2.6.4 Threatened and Endangered Species. Direct impacts to federal- or state-listed species during operation of a conversion facility at Location A are not expected. The wooded area at Location A has not been identified as summer roosting habitat for the Indiana bat (federal- and state-listed as endangered). Disturbances from increased noise, lighting, and human presence due to facility operation, and the movement of railcars along the new rail line south of the facility might decrease the quality of the adjacent forest habitat for use by Indiana bats. However, Indiana bats that might currently be using habitat near the Paducah site would already be exposed to noise and other effects of human disturbance due to operation of the site, including vehicle traffic. Consequently, disturbance effects related to conversion facility operation would be expected to be minor.

In addition, noise from railcar movement along the new rail line may result in a disturbance to Indiana bats that may use habitat, identified as fair potential and poor potential, west of the Entrance Highway, where existing levels of disturbance are relatively low. Indiana bats have been observed to tolerate increased noise levels (U.S. Fish and Wildlife Service [USFWS] 2002). Consequently, disturbances from rail traffic are not expected to result in loss of suitability of these habitat areas. The operation of a conversion facility at Locations B and C might similarly decrease the quality of wooded areas at those locations for Indiana bat summer habitat, although these locations have not been identified as containing Indiana bat habitat.

5.2.2.7 Waste Management

Operations at the conversion facility would generate radioactive, hazardous, and nonhazardous wastes. The annual waste volumes generated by conversion would be the same for all three alternative locations and are presented in Table 5.2-17. The total volumes of wastes that would be generated during the 25 years of operations would be 1,440 yd^3 (1,100 m^3) of LLW and 180 yd^3 (140 m^3) of hazardous waste. These volumes would result in low impacts on site annual projected volumes.

If ETTP cylinders are processed for conversion at Paducah, an additional 26 yd^3 (20 m^3) of LLW and 5 yd^3 (4 m^3) of hazardous waste would be generated. These volumes constitute negligible impacts on site annual generation volumes.

CaF_2 would be produced in the U_3O_8 conversion and is assumed to have a low uranium content. It is currently unknown whether this CaF_2 could be sold (e.g., as feedstock for commercial production of anhydrous HF) or whether the low uranium content would force disposal. If CaF_2 disposal is necessary, it could be either as a nonhazardous solid waste (provided that authorized limits have been established in accordance with DOE Order 5400.5 [DOE 1990] and its associated guidance) or as LLW. It is currently unknown whether it would require disposal as either a nonhazardous solid waste or as LLW because of its low uranium content. The nonhazardous solid waste generation estimates for conversion to U_3O_8 in Table 5.2-17 are based on the assumption that CaF_2 would be disposed of as nonhazardous solid waste, generating approximately 17 yd^3/yr (13 m^3/yr) of nonhazardous solid waste. This represents a negligible impact (less than 1%) to the projected annual nonhazardous solid waste volume at Paducah. If CaF_2 was disposed of as LLW, it would represent less than 1% of the projected annual LLW load and constitute negligible impact.

If the HF was not marketable, it would be converted to CaF_2. Neutralization of HF to CaF_2 would produce approximately 4,900 yd^3/yr (3,780 m^3/yr) of CaF_2. This volume represents approximately 20% and 53% of nonhazardous solid waste and LLW, respectively, of projected annual generation volumes for Paducah. These potential

TABLE 5.2-17 Wastes Generated from Operation of the Conversion Facility at the Paducah Site

Waste Category	Annual Volume
LLW	
Combustible waste	34 m^3
Noncombustible	8.5 m^3
Others	1.0 m^3
Total[a]	44 m^3
Hazardous waste	5.5 m^3
Nonhazardous waste	
Solids[b]	180 m^3
Sanitary wastewater	5.5×10^6 L

[a] Includes LLW from high-efficiency particulate air (HEPA) filters and laboratory acids and residues.

[b] Includes volumes of CaF_2 generated from the conversion process.

Source: UDS (2003b).

waste volumes would result in a moderate to large impact relative to site annual waste generation volumes and on-site waste management capacities. It is also unknown whether CaF_2 LLW would be considered DOE waste if the conversion was performed by a private commercial enterprise. If CaF_2 could be sold, the nonhazardous solid waste or LLW management impacts would be lower.

The U_3O_8 produced from the conversion process would generate about 7,850 yd^3/yr (6,000 m^3/yr) of LLW. This volume is about 83% of the annual site-projected LLW volume and constitutes a relatively large impact on site LLW management. However, plans for off-site (to Envirocare or NTS) disposal of this potential volume of LLW are considered in the proposed action.

Current UDS plans are to leave the heels in the emptied cylinders, fill them with the depleted U_3O_8 product, and dispose of them at either Envirocare or NTS. This approach is expected to meet the waste acceptance criteria of the disposal facilities and eliminate the potential for generating TRU waste (see Appendix B for additional information concerning TRU and PCB contamination). However, it is possible that the heels could be washed from the emptied cylinders if, instead, it was decided to reuse the cylinders for other purposes. In this case, the TRU in the heels of some cylinders at the maximum postulated concentrations could also result in the generation of some TRU waste at the conversion facility. It is estimated that up to 30% (or 244 drums) of the heels could contain enough TRU to qualify this material as TRU waste if it was disposed of as waste. In this case, it is estimated that a volume of about 2.6 yd^3/yr (2.0 m^3/yr) of TRU and 6.0 yd^3/yr (4.4 m^3/yr) of LLW would be generated.

In addition, a small quantity of TRU could be entrained in the gaseous DUF_6 during the cylinder emptying operations and carried out of the cylinders. These contaminants would be captured in the filters between the cylinders and the conversion equipment. The filters would be monitored and replaced routinely to prevent buildup of TRU. The spent filters would be disposed of as LLW. It is estimated that the amount of LLW generated in the form of spent filters would be about 1 drum per year for a total of 25 drums (drums are 55 gal [208 L] in size) for the duration of the conversion operations (see Appendix B). This converts to a total volume of 6.8 yd^3 (5.2 m^3) of LLW. Current site projections include the generation of a small amount of TRU waste (about 0.8 yd^3/yr [0.6 m^3/yr]). In the unlikely event that small amounts of TRU waste are generated from the conversion facility, the wastes would be managed in accordance with DOE's policy for TRU waste, which includes the packaging and transport of these wastes to the Waste Isolation Pilot Plant (WIPP) in New Mexico for disposal.

5.2.2.8 Resource Requirements

Resource requirements during operation would not depend on the location of the conversion facility. Facility operations would consume electricity, fuel, and miscellaneous chemicals that are generally irretrievable resources. Estimated annual consumption rates for operating materials are given in Table 5.2-18. The total quantity of commonly used materials is not expected to be significant and would not affect their local, regional, or national availability. In general, facility operational resources required are not considered rare or unique.

Operation of the proposed conversion facility could include the consumption of fossil fuels used to generate steam and heat and electricity (Table 5.2-19). Energy also would be expended in the form of diesel fuel and gasoline for cylinder transport equipment and transportation vehicles. The existing infrastructure at the site appears to be sufficient to supply the required utilities.

TABLE 5.2-18 Materials Consumed Annually during Normal Conversion Facility Operations at the Paducah Site[a]

Chemical	Quantity (tons/yr)
Solid	
Lime (CaO)[b]	19
Liquid	
Ammonia (99.95% minimum NH_3)	670
Potassium hydroxide (45% KOH)	8
Gas	
Nitrogen (N_2)	10,000

[a] Material estimates are based on facility conceptual-design-status data (UDS 2003b). A number of studies are planned to evaluate design alternatives, the results of which may affect the above materials needs.

[b] Assuming lime is used only for potassium hydroxide regeneration. If HF neutralization is required, the annual lime requirement would be approximately 9,300 tons/yr (8,437 t/yr).

5.2.2.9 Land Use

Because the preferred location (Location A) consists primarily of a previously disturbed grassy field with a wooded area in the southeastern section of the tract, the proposed action would involve a change from current land use. Despite this localized change, operating the facility would be consistent with the activity currently found at the heavily industrialized Paducah site — a result of producing enriched uranium and its DUF_6 by-product. As a consequence, only negligible land use impacts are anticipated.

Impacts of operations on land use for a conversion facility at Location B or Location C would be similar to those of a facility placed at Location A. Although localized changes in land use would occur in both cases, activities would be consistent with those currently found at the heavily industrialized site. Once again, only negligible impacts are expected as a consequence of operating the facility at either of these localities.

5.2.2.10 Cultural Resources

The routine operation of a DUF_6 conversion facility at Paducah is unlikely to adversely affect cultural resources at all three alternative locations because no ground-disturbing activities are associated with facility operation.

Air emissions or chemical releases from the facility were evaluated to determine their potential to affect significant cultural resources in the surrounding area. On the basis of the analysis of air emissions in Section 5.2.2.3 and the secondary standards given in Section 3.1.3, no secondary standards would be exceeded during the operation phase beyond the facility itself.

TABLE 5.2-19 Utilities Consumed during Conversion Facility Operations at the Paducah Site[a]

Utility	Annual Average Consumption	Unit	Peak Demand[b]	Unit
Electricity	37,269	MWh	7.1	MW
Liquid fuel	4,000	gal	NA[c]	NA
Natural gas[d,e]	4.4×10^7	scf [f]	190	scfm[f]
Process water	37×10^6	gal	215	gal/min
Potable water	3×10^6	gal	350	gal/min

[a] Utility estimates are based on facility conceptual-design-status data (UDS 2003b). A number of studies are planned to evaluate design alternatives, the results of which may affect the above utility needs.

[b] Peak demand is the maximum rate expected during any hour.

[c] NA = not applicable.

[d] Standard cubic feet measured at 14.7 psia and 60°F (17°C).

[e] The current facility design (UDS 2003b) uses electrical heating. An option of using natural gas is being evaluated.

[f] scf = standard cubic feet; scfm = standard cubic feet per minute.

Thus, emissions from operation of the facility would not have any adverse effect on cultural resources.

Accidental radiological and chemical releases, including HF, uranium compounds, and NH_3, would be possible, although unlikely, during the operation of the plant (see Section 5.2.2.2). It is projected that HF emissions would not exceed secondary standards beyond site boundaries and would have no effect on cultural resources. Any release of uranium compounds would be as PM and would affect only the surfaces of buildings in close proximity to the facility. NH_3 releases would be gaseous and quickly disperse, although some surface deposits could occur. Careful washing of building surfaces could be required to remove such deposits if any contamination was detected following an accidental release.

5.2.2.11 Environmental Justice

The evaluation of environmental justice impacts is predicated on the identification of high and adverse impacts in other impact areas considered in this EIS, followed by a determination if those impacts would affect minority and low-income populations disproportionately. Analyses of impacts from operating the proposed facility do not indicate high and adverse impacts for any of the other impact areas considered in this EIS (see Section 5.2.2). Despite the presence of disproportionately high percentages of both minority and low-income populations within 50 mi (80 km) of the Paducah site, no environmental justice impacts are anticipated at any of the three alternative locations because of the lack of high and adverse impacts. Similarly, no evidence exists indicating that minority or low-income populations would experience high and adverse impacts from operating the proposed facility in the absence of such impacts in the population as a whole.

5.2.3 Transportation

The action alternatives involve transportation of the conversion products to a disposal site or to commercial users. All products are proposed to be shipped primarily by rail. However, a viable option is to ship some material by truck. For purposes of this EIS, transportation of all cargo is considered for both truck and rail modes of transport. In a similar fashion, conversion products declared to be wastes are expected to be sent to Envirocare in Utah for disposal; another viable option is to send the wastes to the NTS. Thus, both options are evaluated. The emptied heel cylinders, if not used as disposal containers for the U_3O_8 product, would be crushed and shipped in 20-ft (6-m) cargo containers, approximately 10 to a container. However, up to 10% of these cylinders might not meet Envirocare acceptance criteria and would be shipped "as is" to NTS for disposal (UDS 2003b). The HF is expected to be produced in concentrations of both 49% and 70%. Thus, the total impacts for HF transportation are the sum of the impacts presented for each concentration.

As discussed in Appendix F, Section F.3, the impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents (Section 5.2.3.1), (2) radiological risks to MEIs during routine conditions (Section 5.2.3.2), and (3) consequences to individuals and populations after the most severe accidents involving a release of radioactive or hazardous chemical material (Section 5.2.3.3).

5.2.3.1 Collective Population Risk

The collective population risk is a measure of the total risk posed to society as a whole by the actions being considered. For a collective population risk assessment, the persons exposed are considered as a group, without specifying individual receptors. The collective population risk is used as the primary means of comparing various options. Collective population risks are calculated for both vehicle- and cargo-related causes for routine transportation and accidents. Vehicle-related risks are independent of the cargo in the shipment and include risks from vehicular exhaust emissions and traffic accidents (fatalities caused by physical trauma).

Under the action alternatives, anhydrous NH_3 would be transported to the conversion facility for generation of hydrogen, which would be used in the conversion process. Collective population risks associated with the transport of NH_3 to the site are shown in Table 5.2-20 for three different distances between the origin of NH_3 and the site. By assuming a distance of 620 mi (1,000 km) from the site and using average accident rates and population densities, the number of adverse effects that would be expected among the crew and the population along the transportation route would be about 10 for the truck option and about 2 for the rail option. For the same distance, it is expected that there would be about 1 irreversible adverse effect for the

TABLE 5.2-20 Collective Population Transportation Risks for Shipment of Anhydrous NH_3 to the Paducah Conversion Facility

Mode	Distance to Conversion Facility (km) 250	1,000	5,000
Truck Option			
Shipment summary			
Number of shipments	1,300	1,300	1,300
Total distance (km)	324,000	1,296,000	6,480,000
Cargo-related[a]			
Chemical impacts			
Adverse effects	2.4	9.7	49
Irreversible adverse effects	0.36	1.4	7.1
Vehicle-related[b]			
Emission fatalities	0.03	0.1	0.6
Accident fatalities	0.0048	0.019	0.097
Rail Option			
Shipment summary			
Number of shipments	648	648	648
Total distance (km)	162,000	648,000	3,240,000
Cargo-related[a]			
Chemical impacts			
Adverse effects	0.53	2.1	11
Irreversible adverse effects	0.076	0.3	1.5
Vehicle-related[b]			
Emission fatalities	0.002	0.007	0.03
Accident fatalities	0.013	0.051	0.25

[a] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[b] Vehicle-related impacts are impacts independent of the cargo in the shipment.

truck option and less than 1 irreversible adverse effect for the rail option. No fatalities would be expected for either transportation mode. As indicated on Table 5.2-20, the risks would be smaller for distances less than 620 mi (1,000 km) and higher for greater distances.

The transportation assessment for the shipment of depleted uranium conversion products for disposal considers several options. The proposed disposal site is the Envirocare facility. (A small number of empty cylinders may require disposal at NTS.) For shipments to Envirocare, rail is evaluated as the proposed mode and truck is evaluated as an alternative. In addition, NTS is considered as an alternative disposal site. For this alternative, both truck and rail modes are evaluated, although neither is currently proposed.

For assessment of the rail option to NTS, it is assumed that a rail spur that would be built in the future would provide rail access to NTS. Currently, the nearest rail terminal is about 70 mi (113 km) from NTS. If a rail spur was not available in the future and if NTS was selected as the disposal site, shipments could be made by truck, or rail could be used with an intermodal transfer to trucks at some place near NTS. (Transportation impacts for the intermodal option would be slightly greater than those presented for rail assuming NTS rail access, but less than those presented for the truck alternative.) If a rail spur was built to NTS, the impacts would require additional NEPA review.

Estimates of the collective population risks for shipment of the U_3O_8 product, emptied cylinders, and CaF_2 to Envirocare over the entire 25-year operational period are presented in Table 5.2-21, assuming the U_3O_8 was shipped in bulk bags. As an option, risks for the shipment of these materials to NTS are provided in Table 5.2-22. No radiological LCFs, traffic fatalities, or emission fatalities are expected for rail transport under either option. No radiological LCFs would be expected for the truck option either. However, approximately 1 traffic fatality might occur, and up to 11 fatalities from vehicle emissions might occur over the project period if the truck option was used.

If the emptied DUF_6 cylinders were refilled with the U_3O_8 product and used to transport the product to the disposal facility, as proposed, the risks shown in Tables 5.2-21 and 5.2-22 for transportation of emptied cylinders would not be applicable, and the risks associated with transportation of CaF_2 would be the same. The risks of transporting the U_3O_8 product in cylinders would be about the same as the sum of risks for transporting the product in bulk bags and the risk of shipping the crushed cylinders for the truck option (Table 5.2-23) with two refilled cylinders per truck. If one cylinder per truck were shipped, routine risks to the crew and vehicle-related risks would be approximately double, because the number of shipments would double. If the rail option was used, the risks would be slightly higher for the cylinder refill option primarily because the quantity of U_3O_8 shipped in a single railcar would be less under the cylinder refill option than under the use of the bulk bag option, and the number of shipments would be proportionally higher.

The risks for shipping the HF co-product are presented in Table 5.2-24 for representative shipment distances of 250, 1,000, and 5,000 km (155, 620, and 3,100 mi), by using U.S. average accident rates and population densities. For shipment distances up to 5,000 km (3,107 mi), 1 traffic fatality is expected for shipment of the HF by either truck or rail; however, up to 7 emission fatalities could occur for shipment by truck, with none expected for rail shipments. For chemical risks, approximately 2 irreversible adverse effects are estimated for either truck or rail transport. Thus, no chemical fatalities are expected because approximately 1% of the cases with irreversible adverse effects are expected to result in fatality (Policastro et al. 1997). Table 5.2-25 presents the risks associated with the shipment of CaF_2 to either Envirocare or NTS should the HF be neutralized and disposed of as waste, as discussed in Section 5.2.4. Shipment of the CaF_2 to either Envirocare or NTS would have similar impacts; approximately 10 emission fatalities for truck and 0 for rail, and about 2 traffic fatalities for shipment by truck.

TABLE 5.2-21 Collective Population Transportation Risks for Shipment of Conversion Products to Envirocare as the Primary Disposal Site, Assuming the U_3O_8 Is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2	
	Paducah to Envirocare		Paducah to Envirocare[a]		Paducah to NTS[b]		Paducah to Envirocare	
Mode	Truck (option)	Rail (proposed)[c]	Truck (option)	Rail (proposed)[c]	Truck (proposed)	Rail (option)[c]	Truck (option)	Rail (proposed)[c]
Shipment summary								
Number of shipments	16,420	4,105	3,715	1,858	4,150	1,038	28	7
Total distance (km)	41,710,000	11,010,000	9,436,000	4,985,000	11,690,000	3,559,000	71,120	18,780
Cargo-related[d]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	240	560	55	140	120	270	NA[e]	NA
Routine public								
Off-link	4.3	11	1.1	2.7	1.7	4.6	NA	NA
On-link	12	0.35	3.1	0.085	4.4	0.16	NA	NA
Stops	97	9.5	26	2.3	36	4.6	NA	NA
Total	110	21	30	5.1	42	9.4	NA	NA
Accident[f]	35	9.9	0.35	0.076	0.02	0.0085	NA	NA
Latent cancer fatalities[g]								
Crew fatalities	0.1	0.2	0.02	0.06	0.05	0.1	NA	NA
Public fatalities	0.07	0.02	0.02	0.003	0.02	0.005	NA	NA
Chemical impacts								
Adverse effects	0.002	0.0004	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0002	0.0001	NA	NA	NA	NA	NA	NA
Vehicle-related[h]								
Emission fatalities	8	0.2	2	0.1	2	0.06	0.01	0.0004
Accident fatalities	1.0	0.24	0.23	0.11	0.27	0.08	0.0018	0.00041

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TABLE 5.2-21 (Cont.)

[a] Emptied cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[b] Cylinders assumed not to meet the waste acceptance criteria for Envirocare. Shipped "as is," one per truck or four per railcar.

[c] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that rail access to NTS would be available in the future.

[d] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[e] NA = not applicable.

[f] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[g] Latent cancer fatalities were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers, and 5×10^{-4} for the public (ICRP 1991).

[h] Vehicle-related impacts are impacts independent of the cargo in the shipment.

TABLE 5.2-22 Collective Population Transportation Risks for Shipment of Conversion Products to NTS as an Optional Disposal Site, Assuming the U_3O_8 Is Disposed of in Bulk Bags

	U_3O_8		Emptied Cylinders				CaF_2	
	Paducah to NTS		Paducah to NTS[a]		Paducah to NTS[b]		Paducah to Envirocare	
Mode	Truck (option)	Rail (option)[c]	Truck (option)	Rail (option)[c]	Truck (option)	Rail (option)[c]	Truck (option)	Rail (option)[c]
Shipment summary								
Number of shipments	16,420	4,105	3,715	1,858	4,150	1,038	28	7
Total distance (km)	46,240,000	14,080,000	10,460,000	6,371,000	11,690,000	3,559,000	71,120	18,780
Cargo-related[d]								
Radiological impacts								
Dose risk (person-rem)								
Routine crew	270	670	61	170	120	270	NA[e]	NA
Routine public								
Off-link	5.2	11	1.4	2.7	1.7	4.6	NA	NA
On-link	13	0.39	3.6	0.094	4.4	0.16	NA	NA
Stops	110	11	29	2.7	36	4.6	NA	NA
Total	130	22	34	5.4	42	9.4	NA	NA
Accident[f]	14	9.9	0.18	0.076	0.02	0.0085	NA	NA
Latent cancer fatalities[g]								
Crew fatalities	0.1	0.3	0.02	0.07	0.05	0.1	NA	NA
Public fatalities	0.07	0.02	0.02	0.003	0.02	0.005	NA	NA
Chemical impacts								
Adverse effects	0.002	0.0006	NA	NA	NA	NA	NA	NA
Irreversible adverse effects	0.0002	0.0002	NA	NA	NA	NA	NA	NA
Vehicle-related[h]								
Emission fatalities	9	0.2	2	0.1	2	0.06	0.01	0.0004
Accident fatalities	1.1	0.32	0.24	0.14	0.27	0.08	0.0018	0.00041

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TABLE 5.2-22 (Cont.)

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[a] Emptied cylinders are crushed and shipped 10 per cargo container, with 1 container per truck or 2 containers per railcar.

[b] Cylinders shipped "as is." One cylinder per truck or four cylinders per railcar.

[c] Risks are presented on a railcar basis. One shipment is equivalent to one railcar. For assessment purposes, it was assumed that rail access to NTS would be available in the future.

[d] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[e] NA = not applicable.

[f] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[g] Latent cancer fatalities were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers, and 5×10^{-4} for the public (ICRP 1991).

[h] Vehicle-related impacts are impacts independent of the cargo in the shipment.

TABLE 5.2-23 Collective Population Transportation Risks for Shipment of U_3O_8 Conversion Products in Emptied Cylinders

	Paducah to Envirocare (proposed)			Paducah to NTS (option)		
	Truck (option)			Truck (option)		
Mode	1 Cylinder	2 Cylinders	Rail (proposed)	1 Cylinder	2 Cylinders	Rail (option)[a]
Shipment summary						
Number of shipments	36,200	18,100	7,240	36,200	18,100	7,240
Total distance (km)	91,950,000	45,970,000	19,420,000	101,900,000	50,970,000	24,830,000
Cargo-related[b]						
Radiological impacts						
Dose risk (person-rem)						
Routine crew	490	260	770	540	290	930
Routine public						
Off-link	6.8	6.9	17	8.1	8.3	17
On-link	18	18	0.53	21	21	0.59
Stops	150	150	14	170	170	17
Total	180	180	31	200	200	34
Accident	35	35	9.8	14	14	9.8
Latent cancer fatalities						
Crew fatalities	0.2	0.1	0.3	0.2	0.1	0.4
Public fatalities	0.1	0.1	0.02	0.1	0.1	0.02
Chemical impacts						
Adverse effects	0.001	0.001	0.0005	0.001	0.001	0.0007
Irreversible adverse effects	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
Vehicle-related[c]						
Emission fatalities	20	8	0.4	20	10	0.4
Accident fatalities	2.3	1.1	0.42	2.4	1.2	0.56

[a] For assessment purposes, it was assumed that rail access to NTS would be available in the future.

[b] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[c] Vehicle-related impacts are impacts independent of the cargo in the shipment.

The results of the transportation analysis discussed above indicate that the largest impact during normal transportation conditions would be associated with vehicle exhaust and fugitive dust emissions (unrelated to the cargo). Health risks from cardiovascular and pulmonary diseases have been linked to incremental increases in particulate concentrations in air. However, estimating the health risks associated with vehicle emissions is subject to a great deal of uncertainty. The estimates presented in this EIS were based on very conservative health risk factors presented in Biwer and Butler (1999) and should be considered an upper bound. For perspective, in a recently published EIS for a geologic repository at Yucca Mountain, Nevada (DOE 2002g), the same risk factors were used for vehicle emissions; however, they were adjusted to reduce the amount of conservatism in the estimated health impacts. As reported in the

TABLE 5.2-24 Collective Population Transportation Risks for Shipment of the HF Conversion Co-Product from the Paducah Site to Commercial Users

	49% HF			70% HF		
Mode	250 km	1,000 km	5,000 km	250 km	1,000 km	5,000 km
Truck Option						
Shipment summary						
Number of shipments	10,867	10,867	10,867	4,430	4,430	4,430
Total distance (km)	2,716,750	10,867,000	54,335,000	1,107,500	4,430,000	22,150,000
Cargo-related[a]						
Chemical impacts						
Adverse effects	0.25	1.0	5.0	0.92	3.7	18
Irreversible adverse effects	0.021	0.085	0.43	0.074	0.30	1.5
Vehicle-related[b]						
Emission fatalities	0.3	1	5	0.1	0.4	2
Accident fatalities	0.04	0.16	0.81	0.017	0.066	0.33
Rail Option						
Shipment summary						
Number of shipments	2,174	2,174	2,174	886	886	886
Total distance (km)	543,500	2,174,000	10,870,000	221,500	886,000	4,430,000
Cargo-related[a]						
Chemical impacts						
Adverse effects	0.35	1.4	7.0	0.89	3.5	18
Irreversible adverse effects	0.022	0.088	0.44	0.073	0.29	1.5
Vehicle-related[b]						
Emission fatalities	0.005	0.02	0.1	0.002	0.009	0.04
Accident fatalities	0.043	0.17	0.85	0.017	0.069	0.35

[a] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[b] Vehicle-related impacts are impacts independent of the cargo in the shipment.

TABLE 5.2-25 Collective Population Transportation Risks for Shipment of CaF_2 for the Neutralization Option

Parameter	Truck (option)	Rail (proposed)
Number of shipments	25,262	6,316
Paducah to Envirocare Option		
Total distance (km)	64,170,000	16,950,000
Emission fatalities	10	0.4
Accident fatalities	1.6	0.37
Paducah to NTS Option		
Total distance (km)	71,140,000	21,660,000
Emission fatalities	10	0.4
Accident fatalities	1.6	0.49

Yucca Mountain EIS, the adjustments resulted in a reduction in the emission risks by a factor of about 30.

5.2.3.2 Maximally Exposed Individuals during Routine Conditions

During the routine transportation of radioactive material, specific individuals may be exposed to radiation in the vicinity of a shipment. RISKIND (Yuan et al. 1995) has been used to estimate the risk to these individuals for a number of hypothetical exposure-causing events. The receptors include transportation crew members, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near an origin or a destination site. The assumptions about exposure are given in Biwer et al. (2001). The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. Doses were assessed and are presented in Table 5.2-26 on a per-event basis for the shipments of U_3O_8 and emptied cylinders with heels.

The highest potential routine radiological exposure to an MEI, with an LCF risk of 2×10^{-7}, would be for a person stopped in traffic near a rail shipment of 4 heel cylinders for 30 minutes at a distance of 3 ft (1 m). There is also the possibility for multiple exposures. For example, if an individual lived near the Paducah site and all shipments of U_3O_8 were made by rail in bulk bags, the resident could receive a combined dose of approximately 4.5×10^{-5} rem if present for all shipments (calculated as the product of 4,105 shipments and an estimated exposure per shipment of 1.1×10^{-8} rem). The individual’s dose would increase by approximately a factor of 2 if the U_3O_8 product would be shipped in refilled cylinders. However, this dose is still very low, more than 3,000 times lower than the individual average annual exposure of 0.3 rem from natural background radiation.

5.2.3.3 Accident Consequence Assessment

Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts and in terms of adverse affects and irreversible adverse effects for chemical impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Tables 5.2-27 and 5.2-28 present the radiological and chemical consequences, respectively, to the population from severe accidents involving shipment of depleted U_3O_8, emptied heel cylinders, anhydrous NH_3, and aqueous HF. No LCFs would be expected for accidents involving heel cylinders; however, up to 3 LCFs might occur following a severe urban rail accident involving a railcar of U_3O_8. Severe rail accidents could have higher consequences than truck accidents because each railcar would carry more material than each truck.

A comparison of Tables 5.2-27 and 5.2-28 indicates that severe accidents involving chemicals transported to and from the conversion facility site could have higher consequences

TABLE 5.2-26 Estimated Radiological Impacts to the MEI from Routine Shipment of Radioactive Materials from the Paducah Conversion Facility

Material	Mode	Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Routine Radiological Dose from a Single Shipment (rem)						
Depleted U_3O_8 (in bulk bags)[a]	Truck	4.0×10^{-5}	3.1×10^{-9}	1.6×10^{-4}	4.4×10^{-6}	NA[b]
	Rail	9.3×10^{-5}	1.1×10^{-8}	2.7×10^{-4}	NA	6.9×10^{-7}
Crushed heel cylinders[c]	Truck	5.3×10^{-5}	5.7×10^{-9}	1.6×10^{-4}	7.7×10^{-6}	NA
	Rail	6.6×10^{-5}	9.4×10^{-9}	1.7×10^{-4}	NA	6.1×10^{-7}
Heel cylinders[d]	Truck	6.8×10^{-5}	5.4×10^{-9}	2.7×10^{-4}	7.5×10^{-6}	NA
	Rail	1.5×10^{-4}	2.0×10^{-8}	4.0×10^{-4}	NA	1.3×10^{-6}
Routine Radiological Risk from a Single Shipment (lifetime risk of a LCF)[e]						
Depleted U_3O_8 (in bulk bags)	Truck	2×10^{-8}	2×10^{-12}	8×10^{-8}	2×10^{-9}	NA
	Rail	5×10^{-8}	6×10^{-12}	1×10^{-7}	NA	4×10^{-10}
Crushed heel cylinders[c]	Truck	3×10^{-8}	3×10^{-12}	8×10^{-8}	4×10^{-9}	NA
	Rail	3×10^{-8}	5×10^{-12}	8×10^{-8}	NA	3×10^{-10}
Heel cylinders[d]	Truck	3×10^{-8}	3×10^{-12}	1×10^{-7}	4×10^{-9}	NA
	Rail	7×10^{-8}	1×10^{-11}	2×10^{-7}	NA	6×10^{-10}

[a] Per-shipment doses and LCFs would be approximately the same as for the cylinder refill option.

[b] NA = not applicable.

[c] Crushed heel cylinders are shipped 10 cylinders per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Shipped "as is," one cylinder per truck or four cylinders per railcar.

[e] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

than radiological accidents. For example, a severe rail accident involving transportation of anhydrous NH_3 to a site in an urban area under stable weather conditions could lead to 5,000 irreversible adverse effects. Among the individuals experiencing these irreversible effects, there could be close to 100 fatalities (about 2% of the irreversible adverse effects [Policastro et al. 1997]). Similarly, a 70% aqueous HF rail accident under the same conservative assumptions could result in approximately 1,800 irreversible adverse effects and 18 fatalities (about 1% of the irreversible adverse effects [Policastro et al. 1997]). As indicated in Table 5.2-28, the consequences would be considerably less if the accident occurred in a less populated area under neutral meteorological conditions. Consequences would also be less if a truck was involved in the accident rather than a railcar because the truck would carry less material than a railcar.

TABLE 5.2-27 Potential Radiological Consequences to the Population from Severe Transportation Accidents[a]

		Neutral Meteorological Conditions			Stable Meteorological Conditions		
Material	Mode	Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Radiological Dose (person-rem)							
Depleted U_3O_8 (in bulk bags)	Truck	250	250	550	630	610	1,400
	Rail	1,000	990	2,200	2,500	2,400	5,400
Depleted U_3O_8 (1 cylinder)	Truck	120	110	250	280	280	620
	Rail	290	280	630	710	690	1,500
Depleted U_3O_8 (2 cylinders)	Truck	230	230	500	570	550	1,200
	Rail	580	560	1,300	1,400	1,400	3,100
Crushed heel cylinders[c]	Truck	2.5	0.67	1.5	4.4	1.2	2.6
	Rail	5	1.3	3	8.7	2.3	5.2
Heel cylinders[d]	Truck	0.25	0.067	0.15	0.44	0.12	0.26
	Rail	1	0.27	0.6	1.7	0.47	1
Radiological Risk (LCF)[e]							
Depleted U_3O_8 (in bulk bags)	Truck	0.1	0.1	0.3	0.3	0.3	0.7
	Rail	0.5	0.5	1	1	1	3
Depleted U_3O_8 (1 cylinder)	Truck	0.06	0.06	0.1	0.1	0.1	0.3
	Rail	0.1	0.1	0.3	0.4	0.3	0.8
Depleted U_3O_8 (2 cylinders)	Truck	0.1	0.1	0.3	0.3	0.3	0.6
	Rail	0.3	0.3	0.6	0.7	0.7	2
Crushed heel cylinders[c]	Truck	0.001	0.0003	0.0007	0.002	0.0006	0.001
	Rail	0.002	0.0007	0.001	0.004	0.001	0.003
Heel cylinders[d]	Truck	0.0001	3×10^{-5}	7×10^{-5}	0.0002	6×10^{-5}	0.0001
	Rail	0.0005	0.0001	0.0003	0.0009	0.0002	0.0005

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area; very few, if any, urban areas have a population density as high as 1,600 persons/km^2, extending as far as 50 mi (80-km). The urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

[c] Crushed heel cylinders are shipped 10 cylinders per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Shipped "as is," one cylinder per truck or four cylinders per railcar.

[e] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

TABLE 5.2-28 Potential Chemical Consequences to the Population from Severe Transportation Accidents[a]

Chemical Effect	Mode	Neutral Meteorological Conditions			Stable Meteorological Conditions		
		Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Number of Persons with the Potential for Adverse Health Effects							
Depleted U_3O_8 (in bulk bags)	Truck	0	1	1	0	12	28
	Rail	0	3	9	0	47	103
Depleted U_3O_8 (in cylinders)	Truck (1 cylinder)	0	0	1	0	6	13
	Truck (2 cylinders)	0	1	1	0	11	26
	Rail	0	2	5	0	27	58
Anhydrous NH_3	Truck	6	710	1,600	55	6,600	15,000
	Rail	10	1,100	2,500	90	11,000	24,000
49% HF	Truck	0.35	42	93	3.4	400	900
	Rail	0.99	120	270	7.3	880	1,900
70% HF	Truck	2.8	340	760	44	5,200	12,000
	Rail	9.3	1,100	2,500	110	14,000	30,000
Number of Persons with the Potential for Irreversible Adverse Health Effects[c]							
Depleted U_3O_8 (in bulk bags)	Truck	0	0	0	0	5	10
	Rail	0	0	0	0	17	38
Depleted U_3O_8 (in cylinders)	Truck (1 cylinder)	0	0	0	0	2	5
	Truck (2 cylinders)	0	0	0	0	4	8
	Rail	0	1	1	0	10	22
Anhydrous NH_3	Truck	0.8	100	200	10	1,000	3,000
	Rail	1	200	400	20	2,000	5,000
49% HF	Truck	0.025	3.0	6.6	0.25	30	66
	Rail	0.081	9.7	22	0.62	74	160
70% HF	Truck	0.23	27	60	2.0	240	540
	Rail	0.77	92	210	6.7	800	1,800

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TABLE 5.2-28 (Cont.)

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[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area — very few, if any, urban areas have a population density as high as 1,600 persons/km^2 extending as far as 50 mi (80 km). The urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

[c] The potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds is estimated to result in fatality to approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997). Exposure to anhydrous NH_3 is estimated to result in fatality to approximately 2% of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

Accidents for which consequences are provided in Tables 5.2-27 and 5.2-28 are extremely rare. For example, the average accident rate for interstate-registered heavy combination trucks is approximately 3.0×10^{-7} per kilometer (Saricks and Tompkins 1999). The conditional probability that a given accident would be a severe accident is on the order of 0.06 in rural and suburban areas and about 0.007 in urban areas (NRC 1977). Therefore, the frequency of a severe accident per kilometer of travel in an urban area is about 2×10^{-9}. For shipment of NH_3 to the site, the total distance traveled is estimated to be about 808,000 mi (1,300,000 km) if the NH_3 was transported from a location 620 mi (1,000 km) away from the conversion site (Table 5.2-20). The fraction of the distance traveled in urban areas is generally less than 5% (DOE 2002f, Table 6.10). If 5% is assumed, the total distance traveled in urban areas would be about 40,000 mi (65,000 km). On the basis of these assumptions, over the life of the project, the probability of a severe NH_3 truck accident occurring in an urban area is about 1×10^{-4} (1 chance in 10,000). In general, stable weather conditions occur only about one-third of the time, resulting in a probability for the most severe anhydrous NH_3 accident listed in Table 5.2-28 of about 4×10^{-5} (or a 1-in-25,000 chance of occurrence) during the 25-year operational period. Similarly, for shipment of 70% HF 620 mi (1,000 km) from the site, the total distance traveled is estimated to be 3,000,000 mi (4,430,000 km) (Table 5.2-24). The average distance traveled in urban areas would be about 137,000 mi (220,000 km [4,430,000 × 0.05]). Therefore, the probability of a severe 70% HF truck accident occurring in an urban area under stable meteorological conditions is about 1×10^{-4} (or a 1-in-10,000 chance of occurrence) over the 25-year operational period.

The probability of a rail accident involving anhydrous NH_3 or 70% HF of the kind listed in Table 5.2-28 is even less than 4×10^{-5} and 1×10^{-4}, respectively, over the 25-year operational period, because the accident rates for railcars are lower and the total distance travelled by train is less. In fact, the probabilities of severe rail accidents for the same origin-destination pairs and for transportation of the same cargo are approximately 10 to 20 times less than the probabilities for severe truck accidents. As stated above, this can be attributed to train accident rates being about

5 times less (see Table 6 in Saricks and Tompkins 1999), and the total distance traveled by train being generally about 2 to 4 times shorter.

Conservative estimates of consequences to the MEI located 100 ft (30 m) away from the accident site along the transportation route are also made for shipment of depleted U_3O_8, emptied heel cylinders (assuming they are not used as containers for depleted U_3O_8), anhydrous NH_3, and aqueous HF. The results for radiological impacts are shown in Table 5.2-29. Under the conservative assumptions described above for consequences to the population, it is estimated that the MEI could receive up to 1.3 rem from accidents involving emptied cylinders. However, for shipment of the depleted U_3O_8 product by train, the MEI could receive a dose as high as 670 rem if the product was shipped in bulk bags, and 380 rem if it was shipped in emptied DUF_6 cylinders. For shipment by truck, the MEI dose would be 170 rem with bulk bags and 150 rem with refilled cylinders, assuming 2 cylinders per truck. The dose received by the individual would decrease quickly as the person's distance from the accident site increased. For example, at a distance of 330 ft (100 m), the dose would be reduced by about a factor of 6 (to about 110 rem and 60 rem for train accidents with bulk bags and refilled cylinders, respectively, and to about 28 rem and 25 rem for truck accidents with bulk bags and refilled cylinders, respectively.) If the person was located at a distance of 100 ft (30 m) and if the accident occurred under the most severe conditions described above, the individual could suffer acute and potentially lethal consequences from both radiation exposure and the chemical effects of uranium. However, if the MEI was 330 ft (100 m) or farther from the accident, the individual would not be expected to suffer acute effects. However, the chance of the MEI developing a latent cancer would increase by about 10% for the train accident and about 3% for the truck accident. For accidents involving anhydrous NH_3 and aqueous HF, the MEI would likely experience an irreversible health effect or death depending on the severity of the accident, weather conditions, and distance at the time of the accident.

Even though the risks are relatively low (because of low probability of occurrence), the consequences of a few of the transportation accidents considered would be high if they did occur. These high-consequence accidents are generally associated with the transportation of anhydrous NH_3 to the site and aqueous HF from the site. The consequences could be reduced or mitigated through design (e.g., limiting the quantity of material per vehicle), operational procedures (e.g., judicial selection of routes and times of travel, increased protection and tracking of transport vehicles), and emergency response actions (e.g., sheltering, evacuation, and interdiction of contaminated food materials following an accident).

5.2.3.4 Historical Safety Record of Anhydrous NH_3 and HF Transportation in the United States

Anhydrous NH_3 is routinely shipped commercially in the United States for industrial and agricultural applications. Information provided in the DOT *Hazardous Material Incident System (HMIS) Database* (DOT 2003b) for 1990 through 2002 indicates that 2 fatalities and 19 major injuries to the public or to transportation or emergency response personnel occurred as a result of

TABLE 5.2-29 Potential Radiological Consequences to the MEI from Severe Transportation Accidents Involving Shipment of Radioactive Materials

	Neutral Weather Conditions		Stable Weather Conditions	
Mode	Dose (rem)	Radiological Risk (LCF)[a]	Dose (rem)	Radiological Risk (LCF)[a]
Depleted U_3O_8 (in bulk bags)				
Truck	11	0.005	170[b]	0.08
Rail	42	0.02	670[b]	0.3
Depleted U_3O_8 (1 cylinder)				
Truck	4.8	0.002	76	0.04
Rail	12	0.006	190	0.09
Depleted U_3O_8 (2 cylinders)				
Truck	9.6	0.005	150[b]	0.08
Rail	24	0.01	380[b]	0.2
Crushed heel cylinders[c]				
Truck	0.28	0.0001	0.63	0.0003
Rail	0.55	0.0003	1.3	0.0006
Heel cylinders[d]				
Truck	0.028	1×10^{-5}	0.063	3×10^{-5}
Rail	0.11	6×10^{-5}	0.25	0.0001

[a] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

[b] See text for discussion. Because of the conservative assumptions made in deriving the numbers in this table, the MEI is likely to receive a dose that is less than that shown here. However, if the doses were as high as those shown in the table, the MEI could develop acute radiation effects. The individual might also suffer from chemical effects due to uranium intake.

[c] Crushed heel cylinders are shipped 10 cylinders per cargo container, with 1 container per truck or 2 containers per railcar.

[d] Shipped "as is," one cylinder per truck or four cylinders per railcar.

anhydrous NH_3 releases during truck and rail operations. These fatalities and injuries occurred during transportation or loading and unloading operations. Over that period, truck and rail NH_3 spills resulted in more than 1,000 and 6,000 evacuations, respectively. Five very large spills, greater than 10,000 gal (38,000 L), occurred; however, these spills were en route derailments from large rail tank cars. The two largest spills, both around 20,000 gal (76,000 L), occurred in rural or lightly populated areas of Texas and Idaho and resulted in 1 major injury. The Idaho spill in 1990 required the evacuation of 200 people. For highway shipments, one truck transport and 3 loading/unloading accidents occurred that involved large anhydrous NH_3 spills of between 4,000 and 8,000 gal (15,000 and 30,000 L). The 1 en route truck accident involving the largest truck spill (in Iowa on May 3, 1996) resulted in 1 fatality and the evacuation of 40 people. The other 3 large truck shipment spills occurred during loading/unloading operations but did not result in any fatalities. However, one of the spills involved a major injury and required the evacuation of 14 people in addition to the treatment of 26 with minor injuries.

Over the past 30 years, the safety record for transporting anhydrous NH_3 has significantly improved as a result of several factors. Hazardous compressed gas truck shipment loading and unloading operations require strict conformance with DOT standards for safety valve design and specifications in addition to requirements on the installation of measuring and sampling devices. Federal rules governing the transportation of hazardous materials (49 CFR 173) require that valves installed for tank venting, loading, and unloading operations must be “of approved design, made of metal not subject to rapid deterioration by the lading, and must withstand the tank test pressure without leakage.” The MC331 compressed gas tanker trucks, which would most likely be used to ship anhydrous NH_3 to the DUF_6 conversion facility, must be equipped with check valves to prevent the occurrence of a large spill (e.g., a spill from a feed line disconnection during a loading operation). These valves are typically located near the front end of a MC331 tanker truck and close to the driver’s cab. Although not specifically required by DOT regulations, excess flow valves may be installed to prevent a catastrophic spill in the event that the driver is unable to reach the manual check valve to cut off flow from a failed feed line or loading tank valve. Safety measures contributing to the improved safety record over the past 30 years include the installation of protective devices on railcars, fewer derailments, closer manufacturer supervision of container inspections, and participation of shippers in the Chemical Transportation Emergency Center.

Most of the HF transported in the United States is anhydrous HF, which is more hazardous than the aqueous HF. Since 1971, which is the period covered by DOT records (DOT 2003b), no fatal or serious injuries to the public or to transportation or emergency response personnel have occurred as a result of anhydrous HF releases during transportation. Over the period 1971 to 2003, 11 releases from railcars were reported to have no evacuations or injuries associated with them. The only major release (estimated at 6,400 lb [29,000 kg] of HF) occurred in 1985 and resulted in approximately 100 minor injuries. Another minor HF release during transportation occurred in 1990. The safety record for transporting HF has improved in the past 10 years for the same reasons discussed above for NH_3.

5.2.4 Impacts Associated with HF and CaF_2 Conversion Product Sale and Use

During the conversion of the DUF_6 inventory to depleted uranium oxide, products having some potential for reuse would be produced. These products would include HF and CaF_2, which are commonly used as commercial materials. An analysis of impacts associated with the potential reuse of HF and CaF_2 has been included as part of this EIS. Areas examined include the characteristics of these materials as produced within the conversion process, the current markets for these products, and the potential socioeconomic impacts within the United States if the products were sold. Because there would be some residual radioactivity associated with these materials, a description of the DOE process for authorizing the release of contaminated materials for unrestricted use (referred to as "free release") and a bounding estimate of the potential human health effects of such free release have also been included in the analysis. Details on the analysis are presented in Appendix E and are summarized below.

One of the chemicals produced during conversion would be an aqueous HF-water solution of approximately 55% strength. The predominate markets for HF acid call for 49% and 70% HF solutions; thus, this product would be further processed to yield these strengths. In the preferred design, a small amount of solid CaF_2 would also be produced.

Table 5.2-30 gives the approximate quantities of HF and CaF_2 that would be produced annually in the preferred designs. The quantities in Table 5.2-30 are based on the assumption that there would be a viable economic market for the aqueous HF produced. If such a market did not exist, UDS proposes that it would convert all of the HF to CaF_2 and then either sell this product or dispose of it as LLW or as solid waste. The approximate quantity of CaF_2 produced in this scenario would be 11,800 t (13,000 tons).

Because it is expected that the UDS-produced HF and CaF_2 would contain small amounts of volumetrically distributed residual radioactive material, neither could be sold for unrestricted use, and CaF_2 could not be disposed of as solid waste unless DOE established authorized limits for radiological contamination in HF and CaF_2. UDS will be required to apply for appropriate authorized limits, according to whether the HF and CaF_2 were sold or CaF_2 was disposed of as solid waste. In this context, authorized limits would be the maximum concentrations of radioactive contaminants allowed to remain volumetrically distributed within the HF and CaF_2 being sold. The dose analysis presented in this EIS was not conducted to establish authorized limits.

TABLE 5.2-30 Products from DUF_6 Conversion (t/yr)

Product	Portsmouth	Paducah	Total
Depleted uranium oxide	10,700	14,300	25,000
HF acid (55% solution)	8,200	11,000	19,300
CaF_2	18	24	42

Estimates of the potential, bounding exposure for a hypothetical worker working in close proximity to an HF storage tank were made under very conservative assumptions. The estimated annual exposure under such extreme conditions is 0.034 mrem/yr. Similar bounding estimates of the exposure to a worker in close proximity to a CaF_2 handling process yielded an estimate of 0.23 mrem/yr. The bounding exposure to HF resulted from external radiation and inhalation. For CaF_2, in addition to external radiation and inhalation, the bounding exposure also resulted from an assumed incidental ingestion. Given more realistic exposure conditions, the potential dose would be much smaller than the bounding estimates. Potential exposures to product users would be much smaller than those to workers. Detailed discussions on the assumptions for bounding exposures are provided in Appendix E.

Socioeconomic impact analyses were conducted to evaluate the impacts of the introduction of the UDS-produced HF or CaF_2 into the commercial marketplace. The current aqueous HF acid producers have been identified as a potential market for the aqueous HF (UDS 2003a), with UDS-produced aqueous HF replacing some or all of current U.S. production. The impact of HF sales on the local economy in which the existing producers were located and on the U.S. economy as a whole would likely be minimal.

No market for the 22,000 t (24,251 tons) of CaF_2 that might be produced in the proposed conversion facilities at Paducah and Portsmouth has been identified (UDS 2003a). Should such a market be found, the impact of CaF_2 sales on the U.S. economy is likely to be minimal.

In the event that no market for either HF or CaF_2 is established, the HF would be neutralized in a process that would produce additional CaF_2. It is likely that the CaF_2 would be disposed of as waste. This would require shipping it to an approved solid waste or LLW disposal facility. While disposal activities would produce a small number of transportation jobs and might lead to additional jobs at the waste disposal facility, the impact of these activities in the transportation corridors, at the waste disposal site(s), and on the U.S. economy would be minimal.

5.2.5 Impacts If ETTP Cylinders Are Shipped to Paducah Rather Than to Portsmouth

Current DOE plans call for the cylinders stored at ETTP to be shipped to Portsmouth. However, the option of sending the ETTP cylinders to Paducah for conversion is considered in this section. If the ETTP DUF_6 cylinders were converted at Paducah, the Paducah facility would have to operate an additional 3 years, resulting in a total operational period of 28 years. Potential environmental impacts associated with conversion facility operations, cylinder preparation activities at ETTP, and transportation of the cylinders to Paducah are discussed below.

5.2.5.1 Construction and Operation Impacts

If the ETTP cylinders were shipped to Paducah rather than to Portsmouth, the Paducah facility would have to operate an additional 3 years, resulting in a total operational period of 28 years. Facility construction impacts would be the same as those discussed in Section 5.2.1.

The annual operational impacts would be the same as those described in Section 5.2.2 because the facility throughput would be the same; however, impacts would occur over the additional 3 years necessary to process the ETTP DUF_6 cylinders. The shipment of the cylinders to Paducah would result in some incremental increase in the annual radiation dose to workers, as described below.

The involved workers in the cylinder yards would need to unload the cylinders arriving from ETTP, inspect them, transfer them to cylinder yards, and put them into storage. Regular cylinder maintenance activities would be performed until they are transferred to the conversion facility. The shipment of ETTP cylinders to Paducah could last up to 6 years (from 2004 up to December 2009, when all the cylinders need to be removed from ETTP). However, for the purpose of analysis and to provide bounding estimates of annual impacts, it is assumed that the duration of the shipment campaign would be 2 years. Worker exposure at the cylinder yards would increase significantly for the first 2 years because of the handling of ETTP cylinders. It then would decrease steadily but would be slightly greater than that presented in Section 5.2.1.1 because of maintaining the additional ETTP cylinders.

Potential radiation exposures for handling the arriving cylinders were estimated using the following assumptions: (1) unloading a cylinder would require 2 workers to each work half an hour at a distance of 3 ft (1 m) from the cylinder; (2) inspecting a cylinder would require 2 workers to each work half an hour at a distance of 1 ft (0.30 m) from the cylinder; (3) each shipment to the cylinder yard would require 2 workers for about half an hour at a distance of 6 ft (2 m) from the cylinders; and (4) placing each cylinder to its storage position would require 2 workers to each work half an hour at a distance of 3 ft (1 m) from the cylinder. These assumptions were developed for the purpose of modeling potential radiation exposures; in actuality, the number of workers required and the exposure duration of each activity could be less. The collective exposure from handling all the ETTP cylinders was estimated to be about 12.3 person-rem. Distributing it evenly among the 8 workers for 2 years would result in an extra exposure of 770 mrem/yr for each worker.

Because the number of ETTP cylinders is about 12% of the number of Paducah cylinders, potential radiation exposure from routine maintenance activities was assumed to increase by the same percentage. Annual radiation exposure from preparing and transferring cylinders to the conversion facility would not be affected because the cylinder processing rate would stay the same.

Combining the above assumptions, the potential average radiation exposure of the cylinder yard workers would be about 1,460 mrem/yr for the first 2 years. It then would drop from 720 mrem/yr to 430 mrem/yr steadily for the rest of the 26 years. The maximum average cancer risk for individual workers would be less than 6×10^{-4}/yr (1 chance in 1,600 of developing 1 LCF each year). Considering the conservative assumptions used to estimate the potential exposures, actual worker exposures are expected to be less than the estimated values. In reality, worker exposures would be monitored by a dosimetry program and would be kept ALARA.

No on-the-job fatalities are predicted with an additional 3 years during the conversion facility operational phase; it is estimated, however, that a total of about 221 injuries would occur, compared with 197 injuries over 25 years (Table 5.2-1).

It might be necessary to construct a new cylinder yard at Paducah if it was decided to transport the ETTP cylinders to Paducah. If such a decision was made in the future, an additional environmental or NEPA review would be required for construction of a new yard.

5.2.5.2 Cylinder Preparation Impacts at ETTP

Transporting the cylinders at ETTP to Paducah could result in potential environmental impacts at ETTP from the preparation of the cylinders for shipment. As described in Chapter 2, some of the DUF_6 cylinders in storage no longer meet DOT requirements for the shipment of radioactive materials. It is currently unknown exactly how many cylinders do not meet DOT requirements, although current estimates are that 1,700 cylinders are DOT-compliant. Before transportation, cylinders would have to be prepared to meet the requirements. As described in Chapter 2, for the purposes of this EIS, environmental impacts were evaluated for three options for preparing cylinders for shipment: use of cylinder overpacks, cylinder transfer, and obtaining a DOT exemption.

An overpack is a container into which a cylinder would be placed for shipment. The metal overpack would be designed, tested, and certified to meet all DOT shipping requirements. The overpack would be suitable to contain, transport, and store the cylinder contents regardless of cylinder condition. According to UDS (2003b), the use of cylinder overpacks is considered the most likely approach for shipping noncompliant cylinders.

The cylinder transfer option would involve the transfer of the DUF_6 from noncompliant cylinders to cylinders that meet all DOT requirements. If selected, this option would likely require the construction of a cylinder transfer facility at ETTP. Currently, there are no plans or proposals to build or use a cylinder transfer facility to prepare DUF_6 cylinders for shipment. If such a decision were made, additional NEPA review would be conducted. The use of a cylinder transfer facility for cylinder preparation is considered much less likely than the use of overpacks, because the former approach would be more resource intensive and costly and would generate additional contaminated emptied cylinders requiring treatment and disposal.

The third option is to obtain an exemption from DOT that would allow the DUF_6 cylinders to be transported either "as is" or following repairs. The primary finding that DOT would have to make to justify granting an exemption is this: the proposed alternative would have to achieve a safety level that would be at least equal to the level required by the otherwise applicable regulation or, if the otherwise applicable regulation did not establish a required safety level, would be consistent with the public interest and adequately protect against the risks to life and property that are inherent when transporting hazardous materials in commerce. It is likely that some type of compensatory measures during the transportation would have to be employed to justify the granting of an exemption. No specific measures were evaluated in this EIS. However, because the granting of an exemption would be based on a demonstration of equivalent safety, the transportation impacts for this option would be similar to those presented for the overpack and cylinder transfer options. Therefore, transportation impacts for the exemption option are not presented separately in this section.

The site-specific impacts of preparing both compliant and noncompliant cylinders (using overpacks and cylinder transfer) for shipment at ETTP were evaluated in Appendix E of the DUF_6 PEIS (DOE 1999a). In that evaluation, it was assumed for ETTP that the total number of cylinders not meeting DOT requirements ranged from 2,342 to 4,683 (50% to 100% of the ETTP DUF_6 inventory); correspondingly, from 0 to 2,342 compliant cylinders would require preparation for shipment.

The following paragraphs summarize the impacts from the cylinder preparation activities at ETTP as presented in Appendix E of the DUF_6 PEIS (DOE 1999a). The site-specific impacts from operation of a transfer facility at ETTP were evaluated on the basis of the assumption that the facility would be located at the center of the site, since no proposal exists for such a facility and no specific location has been proposed. For the same reasons, the site-specific impacts from construction were not evaluated. Therefore, an additional NEPA review might be required to construct a cylinder transfer facility if a decision was made to do so in the future.

5.2.5.2.1 Cylinder Overpack Option. For normal operations, the PEIS analysis concluded that the potential on-site impacts from preparing compliant cylinders and from placing noncompliant cylinders into overpacks would be small and limited to involved workers. No impacts to the off-site public or the environment would occur, since no releases are expected and no construction activities would be required. The only equipment required would be similar to the equipment currently used during routine cylinder handling and maintenance activities.

It is estimated that at ETTP, the total collective dose to involved workers would range from 42 to 85 person-rem (resulting in less than 0.03 LCF) for overpacking operations and from 0 to 27 person-rem (resulting in less than 0.01 LCF) for preparation of compliant cylinders. The total collective dose to workers preparing all the ETTP cylinders would range from 69 to 85 person-rem (resulting in less than 0.03 LCF). This dose to workers would be incurred over the duration of the cylinder preparation operations (annual doses can be estimated by dividing the total dose by the duration of the operation in years). It should be noted that the assumptions used in the PEIS for estimating worker exposure were very conservative, with the purpose of bounding potential exposures. In practice, cylinder preparation activities, such as inspecting, unstacking, and loading cylinders, would involve fewer workers and be of shorter duration, resulting in significantly lower worker exposures than the estimates presented here.

The PEIS also evaluated the potential for accidents during cylinder preparation operations. The types of accident considered were the same as those considered for the continued storage of cylinders under the no action alternative in this EIS, such as spills from corroded cylinders during wet and dry conditions and vehicle accidents causing cylinders to be involved in fires. The consequences of such accidents are described under the no action alternative in Section 5.1.

5.2.5.2.2 Cylinder Transfer Option. A summary of environmental parameters associated with the construction and operation of a cylinder transfer facility with various throughputs is presented in Table 5.2-31. In the PEIS, it was assumed that the ETTP transfer facility would process 320 cylinders per year, requiring about 15 years to transfer 4,683 cylinders. Although the three facility sizes shown in Table 5.2-31 have vastly different throughputs (ranging over a factor of 5), the differences in the environmental parameters among them are relatively small because of economies of scale. If transfer operations at ETTP occurred over a shorter period of time than 15 years, a larger facility would be required, with environmental parameters similar to those listed for the 1,600-cylinder/yr facility or the 960-cylinder/yr facility.

For the cylinder transfer option, impacts during construction and normal operations would generally be small and limited primarily to involved workers. It is estimated that at ETTP, the total collective dose to involved workers would range from 410 to 480 person-rem (resulting in less than 0.2 LCF) for cylinder transfer operations, and it would range from 0 to 27 person-rem (resulting in less than 0.01 LCF) for preparing compliant cylinders. The total collective dose to workers preparing all the ETTP cylinders would range from 437 to 480 person-rem (resulting in less than 0.2 LCF). This dose to workers would be incurred over the duration of the cylinder preparation operations (annual doses can be estimated by dividing the total dose by the duration of the operation in years).

In the PEIS, the size of the transfer facility was estimated to be less than about 20 acres (8 ha); such a facility would likely be constructed in a previously disturbed area. Some small off-site releases of hazardous and nonhazardous materials could occur, although such releases would have negligible impacts on the off-site public and the environment. Construction activities could temporarily impact air quality, but all criteria pollutant concentrations would be within applicable standards.

TABLE 5.2-31 Summary of Environmental Parameters for a Cylinder Transfer Facility

	Annual Facility Throughput		
Affected Parameter	1,600 Cylinders	960 Cylinders	320 Cylinders
Disturbed land area (acres)	21	14	12
Paved area (acres)	15	10	8
Construction water (million gal/yr)	10	8	6.5
Construction wastewater (million gal/yr)	5	4	3.3
Operations water (million gal/yr)	9	7	6
Operations wastewater (million gal/yr)	7.1	5.7	4.4
Radioactive release (Ci/yr)	0.00078	0.00063	0.00049

Source: Appendix E in DOE (1999a).

Impacts on cultural resources would be possible if a transfer facility was built at ETTP. Depending on the location chosen, the K-25 Main Plant Historical District, significant archaeological resources, or traditional cultural properties could be adversely affected. The ORR CRMP has been approved by the Tennessee SHPO. It includes procedures for determining the effect of an undertaking on cultural resources, consulting with the Tennessee SHPO and Native American groups, and mitigating adverse effects (Souza et al. 2001). These procedures, including additional surveys and any necessary mitigation, would have to be completed before any ground-disturbing activities for construction of a new facility could begin.

5.2.5.3 Transportation of Cylinders from ETTP to Paducah

The estimated potential environmental impacts from transportation of UF_6 cylinders are presented in this section for shipments from ETTP to the Paducah site. Potential impacts for the shipment of DUF_6 cylinders are presented in Section 5.2.5.3.1; potential impacts for the shipment of non-DUF_6 cylinders are presented in Section 5.2.5.3.2. The impacts of transportation were calculated in three areas: (1) collective population risks during routine conditions and accidents, (2) radiological risks to MEIs during routine conditions, and (3) consequences to individuals and populations after the most severe accidents involving a release of UF_6. Shipments of cylinders by both truck and rail were assessed.

5.2.5.3.1 DUF_6 Cylinder Shipments

Collective Population Risk. The total collective population risks for shipment of the entire ETTP inventory to Paducah are presented in Table 5.2-32 for the DUF_6 and non-DUF_6 cylinders. Annual impacts would depend on the duration of the shipping campaign and can be computed by dividing the total risk by the campaign duration. No fatalities are expected as a result of the shipping campaign because all estimated collective fatality risks are much less than 0.5. The estimated radiation doses from the shipments are much less than levels expected to cause an appreciable increase in the risk of cancer in crew members and the public. The highest fatality risks are from vehicle-related causes; the risks for truck shipments are higher than for rail.

The highest radiological risks are for routine transport by general train (0.04 crew LCFs) followed by truck (0.008 crew LCFs). In RADTRAN, rail crew risks are calculated for railcar inspectors in rail yards. During transport, members of the rail crew are assumed to be shielded completely by the locomotive(s) and any intervening railcars. The radiological risks from accidents are approximately 10 times lower than those for routine transport. No chemical impacts would occur under normal transport conditions because the package contents are assumed to remain confined. Chemical accident risks for the entire shipping campaign would be negligible for any transport option. No adverse effects (1.7×10^{-6} or less) or irreversible adverse effects (1.2×10^{-6} or less) are expected.

TABLE 5.2-32 ETTP UF_6 Cylinder Shipments to Paducah

	DUF_6		Non-DUF_6	
Mode	Truck	Rail[a]	Truck	Rail[a]
Shipment summary				
Number of shipments	4,900	1,225	503	181
Total distance traveled (km)	2,370,000	1,010,000	243,000	149,000
Cargo-related[b]				
Radiological impacts				
Dose risk (person-rem)				
Routine crew	21	88	2.8	18
Routine public				
Off-link	0.26	0.89	0.1	0.18
On-link	0.72	0.036	0.28	0.0074
Stops	6.5	1.2	2.6	0.25
Total	7.4	2.2	3.0	0.44
Accident[c]	0.11	0.015	0.00053	3.7×10^{-5}
Latent cancer fatalities[d]				
Crew fatalities	0.008	0.04	0.001	0.007
Public fatalities	0.004	0.001	0.001	0.0002
Chemical impacts				
Adverse effects	1.7×10^{-6}	6.1×10^{-8}	0	0
Irreversible adverse effects	1.2×10^{-6}	4.8×10^{-8}	0	0
Vehicle-related[e]				
Emission fatalities	0.2	0.01	0.02	0.002
Accident fatalities	0.054	0.031	0.0055	0.0047

[a] Risks are presented on a railcar basis. One shipment is equivalent to one railcar.

[b] Cargo-related impacts are impacts attributable to the radioactive or chemical nature of the material being transported.

[c] Dose risk is a societal risk and is the product of accident probability and accident consequence.

[d] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

[e] Vehicle-related impacts are impacts independent of the cargo in the shipment.

Maximally Exposed Individuals during Routine Conditions. During the routine transportation of radioactive material, specific individuals may be exposed to radiation in the vicinity of a shipment. RISKIND (Yuan et al. 1995) has been used to estimate the risk to these individuals for a number of hypothetical exposure-causing events. The receptors include transportation crew members, inspectors, and members of the public exposed during traffic delays, while working at a service station, or while living near an origin or destination site. The assumptions about exposure are given in DOE (1999a) and Biwer et al. (2001). The scenarios for exposure are not meant to be exhaustive; they were selected to provide a range of representative potential exposures. Doses were assessed and are presented in Table 5.2-33 on a per-event basis — no attempt was made to estimate the frequency of exposure-causing events. The highest potential routine radiological exposure to an MEI, with an LCF risk of 1×10^{-7}, would be for a person stopped in traffic near a shipment for 30 minutes at a distance of 3.3 ft (1 m). There is also the possibility for multiple exposures. For example, if an individual lived near either the ETTP or Paducah sites and all shipments were made by truck, the resident could receive a combined dose of less than 0.03 mrem if present for all shipments (calculated as the product of 4,900 shipments and an estimated exposure per truck shipment of 5.4×10^{-9} rem). However, this dose is very low, approximately 10,000 times lower than the individual average annual exposure of 0.3 rem from natural background radiation. Truck inspectors would receive a higher dose per shipment (6.3×10^{-5} rem/event) than the hypothetical resident and might also be exposed to multiple shipments. If the same inspector were present for all shipments, that person would receive a combined dose of approximately 300 mrem distributed over the duration of the shipping campaign, about the same as would be received from an average annual exposure to natural background radiation.

Accident Consequence Assessment. Whereas the collective accident risk assessment considers the entire range of accident severities and their related probabilities, the accident consequence assessment assumes that an accident of the highest severity category has occurred. The consequences, in terms of committed dose (rem) and LCFs for radiological impacts and in terms of adverse affects and irreversible adverse effects for chemical impacts, were calculated for both exposed populations and individuals in the vicinity of an accident. Tables 5.2-34 and 5.2-35 present the radiological and chemical consequences, respectively, to the population from severe accidents involving shipment of DUF_6. Tables 5.2-36 and 5.2-37 present the radiological

TABLE 5.2-33 Estimated Radiological Impacts to the MEI from Routine Shipment of DUF_6 Cylinders

Mode	Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Routine Radiological Dose from a Single Shipment (rem)					
Truck	6.3×10^{-5}	5.4×10^{-9}	2.3×10^{-4}	7.5×10^{-6}	NA[a]
Rail	1.1×10^{-4}	1.5×10^{-8}	2.6×10^{-4}	NA	9.3×10^{-7}
Routine Radiological Risk from a Single Shipment (lifetime risk of an LCF)[b]					
Truck	3×10^{-8}	3×10^{-12}	1×10^{-7}	4×10^{-9}	NA
Rail	6×10^{-8}	8×10^{-12}	1×10^{-7}	NA	5×10^{-10}

[a] NA = not applicable.

[b] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

TABLE 5.2-34 Potential Radiological Consequences to the Population from Severe Transportation Accidents Involving Shipment of DUF_6 Cylinders[a]

	Neutral Meteorological Conditions			Stable Meteorological Conditions		
Mode	Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Radiological Dose (person-rem)						
Truck	590	580	1,300	15,000	15,000	32,000
Rail	2,400	2,300	5,200	60,000	58,000	130,000
Radiological Risk (LCF)[c]						
Truck	0.3	0.3	0.6	7	7	20
Rail	1	1	3	30	30	60

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area — very few, if any, urban areas have a population density as high as 1,600 persons/km^2, extending as far as 50 mi (80 km). That urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

[c] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

Source: DOE (1999b).

and chemical consequences, respectively, to the MEI from severe accidents involving shipment of DUF_6.

The potential consequences of severe cylinder accidents were estimated for rail shipments on the basis of the assumption that the accident occurred in an urban area under stable weather conditions (such as at nighttime). In such a case, it was estimated that approximately four persons might experience irreversible adverse effects (such as lung or kidney damage) from exposure to HF and uranium. The number of fatalities expected following an HF or uranium chemical exposure is expected to be somewhat less than 1% of the potential irreversible adverse effects. Thus, no fatalities would be expected (1% of 4).

TABLE 5.2-35 Potential Chemical Consequences to the Population from Severe Transportation Accidents Involving Shipment of DUF_6 Cylinders[a]

	Neutral Weather Conditions			Stable Weather Conditions		
Mode	Rural	Suburban	Urban[b]	Rural	Suburban	Urban[b]
Number of Persons with the Potential for Adverse Health Effects						
Truck	0	2	4	6	760	1,700
Rail	4	420	940	110	13,000	28,000
Number of Persons with the Potential for Irreversible Adverse Health Effects[c]						
Truck	0	1	2	0	1	3
Rail	0	1	3	0	2	4

[a] National average population densities were used for the accident consequence assessment, corresponding to densities of 6 persons/km^2, 719 persons/km^2, and 1,600 persons/km^2 for rural, suburban, and urban zones, respectively. Potential impacts were estimated for the population within a 50-mi (80-km) radius, assuming a uniform population density for each zone.

[b] It is important to note that the urban population density generally applies to a relatively small urbanized area — very few, if any, urban areas have a population density as high as 1,600 persons/km^2, extending as far as 50 mi (80 km). That urban population density corresponds to approximately 32 million people within the 50-mi (80-km) radius, well in excess of the total populations along the routes considered in this assessment.

[c] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds is estimated to result in fatality of approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

Source: DOE (1999b).

Over the long term, radiation effects are possible from exposure to the uranium released. In a highly populated urban area, it was estimated that about 3 million people could be exposed to small amounts of uranium as it was dispersed by the wind. Among those exposed, it was estimated that approximately 60 LCFs could occur in the urban population in addition to those occurring from all other causes. For comparison, in a population of 3 million people, approximately 700,000 would be expected to die of cancer from all causes. The occurrence of a severe rail accident in an urban area under stable weather conditions would be expected to be rare. The consequences of cylinder accidents occurring in rural environments during unstable weather conditions (typical of daytime) or involving a truck shipment were also assessed. The consequences of all other accident conditions were estimated to be considerably less than those described above for the severe urban rail accident.

TABLE 5.2-36 Potential Radiological Consequences to the MEI from Severe Transportation Accidents Involving Shipment of DUF_6 Cylinders

	Neutral Weather Conditions		Stable Weather Conditions	
Mode	Dose (mrem)	Radiological Risk of LCF[a]	Dose (mrem)	Radiological Risk of LCF[a]
Truck	0.43	2×10^{-4}	0.91	5×10^{-4}
Rail	1.7	9×10^{-4}	3.7	2×10^{-3}

[a] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

Source: DOE (1999b).

TABLE 5.2-37 Potential Chemical Consequences to the MEI from Severe Transportation Accidents Involving Shipment of DUF_6 Cylinders

	Neutral Weather Conditions		Stable Weather Conditions	
Mode	Adverse Effects	Irreversible Adverse Effects[a]	Adverse Effects	Irreversible Adverse Effects[a]
Truck	Yes	Yes	Yes	Yes
Rail	Yes	Yes	Yes	Yes

[a] Potential for irreversible adverse effects from chemical exposures. Exposure to HF or uranium compounds is estimated to result in fatality of approximately 1% or less of those persons experiencing irreversible adverse effects (Policastro et al. 1997).

Source: DOE (1999b).

5.2.5.3.2 Non-DUF_6 Cylinder Shipments

Collective Population Risk. The total collective population risks for shipment of the non-DUF_6 cylinders to Paducah are presented earlier in Table 5.2-32. Annual impacts would depend on the duration of the shipping campaign and can be computed by dividing the total risk by the campaign duration. On a per-shipment basis, the radiological risks during routine transportation would be slightly higher for non-DUF_6 shipments than for DUF_6 cylinder shipments because a higher external dose rate was assumed for the non-DUF_6 shipments. Conversely, radiological accident risks per shipment would be much less for the non-DUF_6 shipments than for the DUF_6 cylinder shipments. This is because the average uranium content per non-DUF_6 cylinder shipment is much less than that for a DUF_6 cylinder shipment: the *total* amount of UF_6 in the non-DUF_6 cylinders is approximately 25 t (28 tons), compared with approximately 12 t (13 tons) in *each* DUF_6 cylinder.

In general, the total potential impacts from radiological and vehicular causes would be small for the shipment of non-DUF_6 cylinders; no fatalities are expected as a result of the shipping campaign because all estimated collective fatality risks are much less than 0.5. Overall, the estimated total impacts from non-DUF_6 shipments are about a factor of 10 less than the total impacts from DUF_6 cylinder shipments (primarily because of the difference in the numbers of shipments).

Maximally Exposed Individuals during Routine Conditions. For MEIs, radiological doses and risks were assessed and are presented in Table 5.2-38 on a per-event basis for the shipment of non-DUF_6 cylinders — no attempt was made to estimate the frequency of

TABLE 5.2-38 Estimated Radiological Impacts to the MEI from Routine Shipment of Non-DUF_6 Cylinders

Mode	Inspector	Resident	Person in Traffic	Person at Gas Station	Person near Rail Stop
Routine Radiological Dose from a Single Shipment (rem)					
Truck	1.4×10^{-4}	2.0×10^{-8}	5.0×10^{-4}	2.7×10^{-5}	NA[a]
Rail	1.8×10^{-4}	2.5×10^{-8}	5.0×10^{-4}	NA	1.6×10^{-6}
Routine Radiological Risk from a Single Shipment (lifetime risk of an LCF)[b]					
Truck	9×10^{-8}	1×10^{-11}	3×10^{-7}	1×10^{-8}	NA
Rail	9×10^{-8}	1×10^{-11}	3×10^{-7}	NA	8×10^{-10}

[a] NA = not applicable.

[b] LCFs were calculated by multiplying the dose by the ICRP Publication 60 health risk conversion factors of 4×10^{-4} fatal cancers per person-rem for workers and 5×10^{-4} for the public (ICRP 1991).

exposure-causing events. On a per-shipment basis, the radiological risks to an MEI during routine transportation would be slightly higher for non-DUF_6 shipments than for DUF_6 cylinder shipments because a higher external dose rate was assumed. The highest potential routine radiological exposure to an MEI, with a LCF risk of 3×10^{-7}, would be for a person stopped in traffic near a shipment for 30 minutes at a distance of 3 ft (1 m).

There is also the possibility for multiple exposures. For example, if an individual lived near either the ETTP or Paducah sites and all non-DUF_6 shipments were made by truck, that person could receive a combined dose of approximately 0.01 mrem if present for all shipments (calculated as the product of 500 shipments and an estimated exposure per shipment of 2.0×10^{-8} rem). However, this dose is still very low, approximately 10,000 times lower than the individual average annual exposure of 0.3 rem from natural background radiation. Truck inspectors would receive a higher dose per shipment (1.4×10^{-4} rem/event) than the hypothetical resident and might also be exposed to multiple shipments. If the same inspector were present for all shipments, that person would receive a combined dose of approximately 70 mrem distributed over the duration of the shipping campaign, much less than the average annual exposure to natural background radiation.

Accident Consequence Assessment. Because the average uranium content of each non-DUF_6 cylinder shipment is much less than that for a DUF_6 cylinder shipment (the *total* amount of UF_6 in the non-DUF_6 cylinders is approximately 25 t [28 tons], compared with approximately 12 t [13 tons] in *each* DUF_6 cylinder), a separate accident consequence assessment was not conducted for non-DUF_6 cylinder shipments. The potential impacts of the highest consequence accidents for non-DUF_6 cylinder shipments would be much less than those presented in Tables 5.2-34 through 5.2-37 for DUF_6 shipments.

The nuclear properties of DUF_6 are such that the occurrence of a nuclear criticality is not a concern, regardless of the amount of DUF_6 present. However, criticality is a concern for the handling, packaging, and shipping of enriched UF_6. For enriched UF_6, criticality control is accomplished by employing, individually or collectively, specific limits on uranium-235 enrichment, mass, volume, geometry, moderation, and spacing for each type of cylinder. The amount of UF_6 that may be contained in an individual cylinder and the total number of cylinders that may be transported together are determined by the nuclear properties of enriched UF_6. Spacing of cylinders of enriched UF_6 in transit during routine and accident conditions is ensured by use of regulatory approval packages that provide protection against impact and fire. Consequently, because of these controls and the relatively small number of shipments containing enriched UF_6, the occurrence of an inadvertent criticality is not considered to be credible and therefore is not analyzed in the accident consequence assessment conducted in this EIS.

5.2.6 Potential Impacts Associated with the Option of Expanding Conversion Facility Operations

As discussed in Section 2.2.5, several reasonably foreseeable activities could result in a future decision to increase the conversion facility throughput or extend the operational period at one or both of the conversion facility sites. Specifically, the throughput of the facility could be increased through process improvements at Paducah. The facility also could be operated beyond the currently planned 25-year period in order to process additional DUF_6 that might be transferred to DOE at some time in the future (such as DUF_6 generated by USEC or another commercial enrichment facility). In addition, it is possible that DUF_6 cylinders could be transferred from Paducah to Portsmouth to facilitate conversion of the entire inventory, particularly if DOE assumes responsibility for additional DUF_6 at Paducah.

To account for these future possibilities and provide future planning flexibility, this section includes an evaluation of the environmental impacts associated with expanding conversion facility operations at Paducah, either by increasing throughput or by extending operations. In addition, potential environmental impacts associated with possible Paducah-to-Portsmouth cylinder shipments are also evaluated in this section.

5.2.6.1 Potential Impacts Associated with Increasing Plant Throughput

DOE believes that higher throughput rates can be achieved by improving the efficiency of the planned equipment (DOE 2004b). The conversion contract provides significant incentives to the conversion contractor to improve efficiency. For example, the current facility designs are based on an assumption that the conversion plant would have an 84% on-line availability (percent of time system is on line and operational). However, on the basis of Framatome's experience at the Richland plant, the on-line availability is expected to be at least 90%. Therefore, there is additional capacity expected to be realized in the current design.

If the plant throughput was marginally increased by process improvements, the environmental impacts during operations could increase for some areas but still would be similar to those discussed in Section 5.2.2 for the base design. For example, annual radiation doses to workers and the public from site emissions might increase in proportion to throughput. Slight variations in plant throughput are not unusual from year to year because of operational factors (e.g., equipment maintenance or replacement) and are generally accounted for by the conservative nature of the impact calculations. As discussed in Section 5.2.2, the estimated annual impacts during operations are well within applicable guidelines and regulations, with collective and cumulative impacts being quite low.

5.2.6.2 Potential Impacts Associated with Extending the Plant Operational Period

As noted above, the Paducah conversion facility is currently being designed to process the Paducah cylinder inventory over 25 years. There are no current plans to operate the conversion facilities beyond this period. However, with routine facility and equipment maintenance and periodic equipment replacements or upgrades, it is believed that the conversion facility could be operated safely beyond this time period to process any additional DUF_6 for which DOE might assume responsibility.

The estimated annual environmental impacts during conversion facility operations are presented and discussed in Section 5.2.2; these impacts are expected to continue each year for the planned 25 years of operations at Paducah. If operations were extended beyond 25 years and if the operational characteristics (e.g., estimated releases of contaminants to air and water) of the facility remained unchanged, it is expected that the annual impacts would be essentially the same as those presented in Section 5.2.2. However, continued operations would result in the impacts being incurred over a greater number of years. The total radiation dose to the workers and the public would increase in proportion to the number of additional years that the facility operated. Although the annual frequency of accidents would remain unchanged, the overall probability of a severe accident would increase proportionately with the additional operational time period. In addition, the total quantities of depleted uranium and secondary waste products requiring disposal would increase proportionately, as would the amount of HF or CaF_2 produced. As discussed in Section 5.2.2, the estimated annual impacts during operations are within applicable guidelines and regulations, with collective and cumulative impacts being quite low. This would also be expected during extended operations.

5.2.6.3 Potential Impacts Associated with Possible Future Paducah-to-Portsmouth Cylinder Shipments

As noted above, it is possible that in the future, DUF_6 cylinders could be transferred from Paducah to Portsmouth to facilitate conversion of the entire inventory, particularly if DOE assumed responsibility for additional DUF_6 at Paducah. At this time, it is uncertain whether such transfers would take place and how many cylinders would be transferred if such a decision was made. Therefore, for comparative purposes, this section provides estimates of the potential impacts from transporting 1,000 DUF_6 cylinders from Paducah to Portsmouth by either truck or rail. Shipment of 1,000 cylinders per year roughly corresponds to the annual base design throughput of the Portsmouth conversion facility.

The transportation assessment methodology discussed in Appendix F, Section F.3, was used to estimate the collective population risk for shipment of 1,000 cylinders between Paducah and Portsmouth by both truck and rail. It was assumed that only compliant cylinders that met DOT requirements would be shipped between the sites. The estimated highway and rail route distances between the sites are 395 mi (636 km) and 478 mi (769 km), respectively. The estimated collective risks are provided in Table 5.2-39. No cargo-related or vehicle-related fatalities are expected for the shipment of 1,000 cylinders per year between the sites.

The estimated consequences of severe accidents and the potential impacts to MEIs would be the same as presented and described in Section 5.2.5 for the shipment of ETTP cylinders.

TABLE 5.2-39 Annual Transportation Impacts for the Shipment of DUF_6 Cylinders from Paducah to Portsmouth, Assuming 1,000 DUF_6 Cylinders Shipped per Year

				Cargo-Related			Vehicle-Related	
				Radiological Risk (LCF)[a]				
Route	Mode	No. of Shipments	Total Distance (10^6 mi)	Crew	Public	Irreversible Adverse Effects	Latent Emission Fatalities	Accident Fatalities
Paducah to Portsmouth	Truck	1,000	0.395	0.002	0.001	5×10^{-7}	0.1	0.01
	Rail[b]	250	0.12	0.007	0.0003	2×10^{-8}	0.008	0.006

[a] The lifetime risk of an LCF for an individual was estimated from the calculated doses by using a dose-to-risk conversion factor of 0.0005 fatality per person-rem for members of the general public, as recommended in ICRP Publication 60 (ICRP 1991). The approximate corresponding dose received for each radiological fatality risk listed in this table may be obtained by multiplying the fatality risk by 2,000 (i.e., 1 ÷ 0.0005).

[b] Assumes four DUF_6 cylinders per railcar.

5.3 CUMULATIVE IMPACTS

5.3.1 Issues and Assumptions

The CEQ guidelines for implementing NEPA define cumulative effects as the impacts on the environment resulting from the incremental impacts of an action when added to other past, present, and reasonably foreseeable future actions (40 CFR 1508.7). Cumulative effects include other actions regardless of what agency (federal or nonfederal), organization, or person undertakes them. Noteworthy cumulative impacts can result from individually minor, but collectively significant, effects of all actions.

The activities considered in this cumulative analysis include those that might affect environmental conditions at or near the Paducah site; they also include activities occurring on the site itself and activities occurring nearby that would have similar effects. Tabular summaries of impacts associated with various actions are presented in Table 5.3-1 for impacts associated with the various technical areas assessed in this EIS. When possible, these summaries are quantitative; however, some are, by necessity, qualitative. For technical areas without data that can be aggregated, this analysis evaluates potential cumulative impacts in a qualitative manner as systematically as possible. When it is not appropriate for estimates of impacts to be accumulated, they are not included in the table. For example, it is not appropriate to accumulate chemical impacts (anticipated to be extremely small under the alternatives considered in this EIS) because hazard index estimates are not expected to be additive for different materials and conditions.

TABLE 5.3-1 Cumulative Impacts of DUF_6 Activities and Other Past, Present, or Reasonably Foreseeable Future Actions at the Paducah Site

Impact Category	Existing Conditions	Impacts of DUF_6 Management[a]		Impacts of Other Actions[b]	Cumulative Impacts[c]	
		No Action	Action Alternatives		No Action	Action Alternatives
Radiological, off-site population						
Public, collective dose (person-rem)[d]	4.8	< 0.19	1.2×10^{-3}	21.3	26.3	26.1
Public, number of LCFs[e]	0.002	$< 1 \times 10^{-4}$	6×10^{-7}	0.01	0.01	0.01
Off-site MEI, annual dose (mrem/yr)[f]	1.9	0.1	$<3.9 \times 10^{-5}$	0.42	2.4	2.3
Radiological, worker population						
Worker, collective dose (person-rem)[g]	35	813[h]	380	0.25	848	415
Worker, number of LCFs[i]	0.01	0.3	0.1	1×10^{-4}	0.3	0.4
Transportation[j]						
Number of truck shipments	6,000	< 1/yr	4,200	8,400	14,400	18,600
Number of rail shipments	0	0	6,000	0	0	6,000
Annual dose, truck, MEI (mrem/yr)	0.01	Negligible	9.1×10^{-4}	0.034	0.04	0.04
Annual dose, rail, MEI (mrem/yr)	0	0	2.5×10^{-3}	0	0	2.5×10^{-3}
Air quality (nonattainment)[k]	None	None	None	None	None	24-h PM_{10} and annual $PM_{2.5}$ above their standards during construction
Water and soil[l,m]						
Surface water quality (exceedance)	Aquatic toxicity	None	None	None	Aquatic toxicity	Aquatic toxicity
Groundwater quality (exceedance)	4 Parameters	None	None	None	4 Parameters	4 Parameters
Soil (exceedance)	None	None	None	None	None	None
Ecology (adverse impacts)	Negligible	Negligible	Negligible to minor	Negligible	Negligible	Negligible to minor
Land use (changes from current)	None	None	None	None	None	None

TABLE 5.3-1 (Cont.)

Impact Category	Existing Conditions	Impacts of DUF_6 Management[a]		Impacts of Other Actions[b]	Cumulative Impacts[c]	
		No Action	Action Alternatives		No Action	Action Alternatives
Cultural resources (adverse impacts)	None	Unlikely	Low to high archeological sensitivity; impacts mitigated	Unlikely	Unlikely	Low to high archeological sensitivity; impacts mitigated
Environmental justice (impacts)	None	None	None	None	None	None

a Based on the results in Chapter 5 of this EIS.

b Includes impacts related to the worst-case LLW management at the Paducah site (DOE 1997; see also DOE 2002b); continued enrichment of uranium and storage of DUF_6 by USEC and DOE (management only) (DOE 1999a); continued conversion of uranium ore into UF_6 at the Honeywell International, Inc., plant at Metropolis, Illinois (NRC 1995). Future actions would also include construction and operation of a uranium enrichment facility at the Paducah site, per the 2002 agreement between USEC and DOE that would place such a facility at the Paducah or Portsmouth site (U.S. Energy Research and Development Administration [ERDA] 1977; Platts Nuclear Fuel 2002). Other actions assume that air quality impacts from the TVA's Shawnee power plant and the Joppa Electric Energy, Inc., power plant (see DOE 1999d) would continue.

c Cumulative impacts equal the sum of the impacts of the DUF_6 management alternative and other past, present, and reasonably foreseeable future actions.

d Total collective dose, assuming a 25-year period.

e Assumes 0.0005 LCF/person-rem.

f Off-site MEI includes exposures resulting from airborne and waterborne emissions. Cumulative impacts assume all facilities operate simultaneously and are located at the same point.

g No worker dose given for possible enrichment facility, thus cumulative figures will be slightly low; the individual dose would still be monitored to remain under 5 rem/person annually.

h Estimated for 25 years to enable comparison with proposed action.

i Includes both facility workers and noninvolved workers; assumes 0.0004 LCF/person-rem.

j The following assumptions were made to estimate the transportation impacts under the DUF_6 management alternatives: (1) number of shipments includes all radiological shipments to and from the site (rounded to the nearest hundred); (2) number of truck or rail shipments is for the mode proposed; there may be other shipments by the other mode.

k Air impacts not discussed for the enrichment facility (see ERDA 1977).

l Exceedance of the EPA MCL for drinking water; the exceedance is temporary for certain conversion options and involves local, small waterways.

m Beta activity, chromium, nitrate as nitrogen, and TCE were evaluated in terms of maximum contaminant levels adopted by the Commonwealth of Kentucky.

Sources: DOE (1997, 1999a,d, 2001b, 2002b); NRC (1995).

5.3.2 Paducah Site

Past, ongoing, and future actions at the Paducah site include uranium enrichment operations (under management of USEC), waste management activities, waste disposal activities (DOE 1997, 2002b), environmental restoration activities (DOE 2001b), and continued management of DUF_6 cylinders by USEC. Other actions occurring near the Paducah site that could contribute to past, present, or future impacts near the Paducah site (because of their diffuse nature) include continued operation of the TVA's Shawnee Power Plant; the Joppa Electric Energy, Inc., power plant in Joppa, Illinois (see DOE 1999d); and the Honeywell International, Inc., uranium conversion plant in Metropolis, Illinois (NRC 1995).

One action that is considered in this analysis and that deserves special mention is the future development of a uranium enrichment facility at the Paducah site. In January 2004, USEC announced that it had selected Portsmouth as the site of its American Centrifuge Facility. However, this cumulative assessment assumes that the facility could be sited at Paducah and would use existing gas centrifuge technology; the assessment further assumes that the impacts of such a facility would be the same as those outlined in a 1977 analysis of environmental consequences for such an action (Energy Research and Development Administration [ERDA] 1977). (The facility proposed in 1977 was never completed.)

Together with the alternatives assessed in Sections 5.1 and 5.2 of this EIS, the cumulative analysis (data columns 4 through 6 of Table 5.3-1) includes the following:

- *No Action Alternative*: The cumulative impacts of no action include the impacts of UF_6 generation and management activities by USEC and DOE (management only) (DOE 1999a) and continued storage of cylinders under the no action alternative; waste management activities (DOE 1997); conversion of uranium ore into UF_6 at the Honeywell International, Inc., plant in Metropolis, Illinois (NRC 1995); electrical power generation at the TVA's Shawnee power plant and at the Joppa Electric Energy, Inc., power plant (DOE 1999d); and environmental restoration activities that have proceeded to a point that their consequences can be defined (DOE 2001b). Future actions could also include construction, operation, and D&D of a uranium enrichment facility at the Paducah site.

- *Proposed Action Alternatives*: The cumulative impacts of the proposed action alternatives include impacts related to the preferred alternative for waste management at the Paducah site (DOE 1997; see also DOE 2002b); continued enrichment of uranium and storage of DUF_6 by USEC and DOE (management, only) (DOE 1999a), conversion of DUF_6 without or with cylinders from ETTP (proposed action alternatives in this EIS); continued conversion of uranium ore into UF_6 at the Honeywell International, Inc., plant at Metropolis, Illinois (NRC 1995), electrical power generation at the TVA's Shawnee power plant and at the Joppa Electric Energy, Inc., power plant (DOE 1999d); and environmental restoration activities that have proceeded to a point that their consequences can be defined (DOE 2001b). Future actions could also include construction, operation, and D&D of a uranium enrichment facility at the Paducah site.

5.3.3 Results

The results of the cumulative analysis are summarized in Table 5.3.1. The first two data columns of the table summarize the results of the assessment of impacts of alternatives presented in Sections 5.1 and 5.2 of this EIS. The second two data columns identify the anticipated cumulative impacts of the alternatives when added to other actions.

5.3.3.1 Radiological Releases — Normal Operations

For the no action and the proposed action alternatives, impacts to human health and safety could result from radiological facility operations. As shown in Table 5.3-1, the cumulative collective radiological exposure to the off-site population would be well below the maximum DOE dose limit of 100 mrem/yr to the off-site MEI for both alternatives and below the limit of 25 mrem/yr specified in 40 CFR 190 for uranium fuel cycle facilities. Annual individual doses to involved workers at radiological facilities would be monitored to maintain exposure below the regulatory limits.

5.3.3.2 Accidental Releases — Radiological and Chemical Materials

For the no action and the proposed action alternatives, doses and consequences of releases of radiological materials were considered for a range of accidents from likely (occurring an average of 1 or more times in 100 years) to extremely rare (occurring an average of less than once in a million years). Because of the low probability of two accidents happening at the same time, the consequences of these accidents are not considered to be cumulative. The probability of likely accidents occurring at the same time is very low, even for the most frequently expected accidents, because this risk is the product of their fractional probabilities (1 in 100 years multiplied by 1 in 100 years equals both occurring 1 in 10,000 years [$0.01 \times 0.01 = 0.0001$]). In the unlikely event that two facility accidents from the “likely” category occurred at the same time, the consequences for the public would be low. The additive impacts would be for no chemical effects and for no LCFs.

5.3.3.3 Transportation

The number of shipments of wastes with a radiological component and of empty cylinders, from the conversion facility and from the option of transportation of ETTP cylinders to the Paducah site, would involve about 4,000 truck shipments of intact heel cylinders to NTS and about 6,000 rail shipments of U_3O_8 and crushed heel cylinders to Envirocare. Since none of the other actions have shipped or would ship by rail, the annual dose to the MEI is determined by the dose from the proposed action alternatives. For truck transportation, other actions have a larger dose than any DUF_6 management alternative, and annual cumulative dose to the MEI is determined by other actions. All cumulative doses are less than 0.1 mrem/yr.

5.3.3.4 Chemical Exposure — Normal Operations

Impacts associated with chemical exposure are expected to be very small under the no action alternative and the proposed action alternative considered in this EIS. As noted above, the calculation of cumulative impacts is not possible because of the absence of necessary measures (hazard indices) for other actions and the difficulty of aggregating these measures across the different chemicals used in different industries.

5.3.3.5 Air Quality

The Paducah site is currently located in an attainment region where criteria air pollutants do not exceed regulatory standards. During construction at the site for on-site conversion, continued storage, or cylinder preparation, total pollutant concentrations for SO_2, NO_2, and CO would be well below their applicable air quality standards. However, total concentrations of PM (PM_{10} and $PM_{2.5}$) are predicted to approach or exceed air quality standards during yard construction or during facility construction. These impacts would be temporary and could be minimized by using good engineering and construction practices and standard dust suppression methods. During the operational period, total annual average $PM_{2.5}$ concentrations would approach (99%) their applicable standards, primarily because of high background concentrations.

5.3.3.6 Noise

No cumulative noise impacts are expected because noise energy dissipates within short distances from the sources and because significant noise impacts are not expected in the vicinity of the conversion facility under all alternatives.

5.3.3.7 Water and Soil

Local impacts on surface water would not exceed the 20 μg/L of uranium used for comparison in discharges to Little Bayou Creek under low-flow conditions for the no action alternative. Impacts on water and soils would be localized and temporary, with adequate dilution occurring once the creek entered nearby larger waterways. Past impacts from the site included aquatic toxicity at KPDES Outfall 017 during cylinder painting/refurbishment. Under the no action alternative, care would be taken during cylinder painting to prevent a further toxicity effect. For the proposed action alternatives, no radioactive contamination would be released to surface water.

Data from the 2000 annual groundwater monitoring results showed that four pollutants exceeded primary drinking water standards in groundwater at the Paducah site: beta activity (seven wells), chromium (all wells), nitrogen as nitrate (one well), and TCE (trichloroethene) (two wells) (DOE 2001b). The groundwater analysis indicates that current cylinder maintenance programs would control cylinder corrosion under the no action alternative, and that the maximum uranium concentration in groundwater (from cylinder breaches) would be 6 μg/L, considerably below the 20 μg/L guideline level used for comparison (EPA 1996). Direct contamination of groundwater could occur during the construction and operation of a conversion facility — for example, from the dissolution and infiltration of stockpiled chemicals into aquifers. However, good engineering and construction practices should ensure that indirect impacts associated with either a conversion or treatment facility would be minimal and would not change existing groundwater conditions.

Because impacts to soils during construction and operation would be local, there would be no cumulative soil impacts.

5.3.3.8 Ecology

Cumulative ecological impacts should be negligible to minor under any alternative considered in this EIS in conjunction with the effects of other activities. At all three alternative locations, construction of a conversion facility could remove trees that are of a type preferred by the Indiana bat; however, this federally endangered species is not known to utilize these areas. No impacts on individuals or populations of Indiana bat are expected.

5.3.3.9 Land Use

All DUF_6 activities under all alternatives would be confined to the Paducah site, which is already used for similar activities. No land use impacts are expected.

5.3.3.10 Cultural Resources

The probability of encountering significant archaeological resources would vary, depending on the proposed location. Further cultural resource surveys would be required. Consultation with the SHPO and Native Americans has been initiated. If significant cultural resources were encountered, adverse effects would need to be mitigated. If any structures at the Paducah GDP were determined to be historically significant and there was a potential for a short-term adverse effect from the deposit of particulate matter on building surfaces, these adverse effects would be mitigated. All additional survey and mitigation would be conducted in consultation with the Kentucky SHPO.

5.3.3.11 Environmental Justice

No environmental justice cumulative impacts are anticipated for the Paducah site despite the presence of disproportionately high percentages of minority and low-income populations in the vicinity. This is because cumulative impacts in the vicinity of the Paducah site are not both high and adverse.

5.3.3.12 Socioeconomics

Socioeconomic impacts under any of the alternatives considered are anticipated to be generally positive, often temporary, and relatively small. Growth in population would not place demands on existing housing or public services that could not be met by existing capabilities. Cumulative socioeconomic impacts are expected to be similarly small and positive, although some would be more long-lived than others.

5.4 MITIGATION

In general, the impacts presented in this chapter are conservative estimates of impacts expected for each alternative. Factors such as flexibility in siting at and within the three alternative locations at Paducah and facility design and construction options could be used to reduce impacts from these conservative levels. This section identifies what impacts could be mitigated to reduce adverse impacts. On the basis of the analyses conducted for this EIS, the following recommendations can be made:

- Potential future impacts on site air and groundwater could be avoided by inspecting cylinders, carrying out cylinder maintenance activities (such as painting), and promptly cleaning up releases from any breached DUF_6 cylinders. In addition, runoff from cylinder yards should be collected and sampled so that contaminants can be detected and their release to surface water or groundwater can be avoided. If future cylinder painting results in KPDES Permit violations, treating cylinder yard runoff prior to release may be required.

- Temporary impacts on air quality from fugitive dust emissions during reconstruction of cylinder yards or construction of any new facility should be controlled by the best available practices to avoid temporary exceedances of the PM_{10} and $PM_{2.5}$ standard. Technologies that will be used to mitigate air quality impacts during construction include using water sprays on dirt roadways and on bare soils in work areas for dust control; covering open-bodied trucks transporting materials likely to become airborne when full and at all times when in motion; water spraying and covering bunkered or staged excavated and replacement soils; maintaining paved roadways in good repair and in a clean condition; using barriers and windbreaks around construction areas such as soil banks, temporary screening, and/or vegetative cover; mulching or covering exposed bare soil areas until vegetation has time to recover or paving has been installed; and prohibiting any open burning.

- During construction, impacts to water quality and soil can be minimized through implementing storm water management, sediment and erosion controls (e.g., temporary and permanent seeding; mulching and matting; sediment barriers, traps, and basins; silt fences; runoff and earth diversion dikes), and good construction practices (e.g., covering chemicals with tarps to prevent interaction with rain; promptly cleaning up any spills).

- Potential impacts to wetlands at the Paducah site could be minimized or eliminated by maintaining a buffer near adjacent wetlands during construction. Mitigation for unavoidable impacts may be developed in coordination with the appropriate regulatory agencies.

- If trees (either live or dead) with exfoliating bark are encountered on construction areas, they should be saved if possible to avoid destroying potential habitat for the Indiana bat. If necessary, the trees should be cut only before March 31 or after October 15, according to recommendations of the USFWS (Andrews 2004).

- The quantity of radioactive and hazardous materials stored on site, including the products of the conversion process, should be minimized.

- The construction of a DUF_6 conversion facility at Paducah would have the potential to impact cultural resources. Neither an archaeological nor an architectural survey has been completed for the Paducah site as a whole or for any of the alternative locations, although an archaeological sensitivity study has been conducted. In accordance with Section 106 of the NHPA, the adverse effects of this undertaking must be evaluated once a location is chosen.

- Testing should be conducted either prior to or during the conversion facility startup operations to determine if the air vented from the autoclaves should be monitored or if any alternative measures would need to be taken to ensure that worker exposures to PCBs above allowable OSHA limits do not occur.

- The nuclear properties of DUF_6 are such that the occurrence of a nuclear criticality is not a concern, regardless of the amount of DUF_6 present. However, criticality is a concern for the handling, packaging, and shipping of enriched UF_6. For enriched UF_6, criticality control is accomplished by employing, individually or collectively, specific limits on uranium-235 enrichment, mass, volume, geometry, moderation, and spacing for each type of cylinder. The amount of enriched UF_6 that may be contained in an individual cylinder and the total number of cylinders that may be transported together are determined by the nuclear properties of enriched UF_6. Spacing of cylinders of enriched UF_6 in transit during routine and accident conditions is ensured by use of regulatory approval packages that provide protection against impact and fire.

- Because of the relatively high consequences estimated for some accidents, special attention will be given to the design and operational procedures for components that may be involved in such accidents. For example, the tanks holding hazardous chemicals, such as anhydrous NH_3 and aqueous HF, on site would be designed to meet all applicable codes and standards, and special procedures would be in place for gaining access to the tanks and for filling the tanks. In addition, although the probabilities of occurrence for a high-consequence accident are extremely low, emergency response plans and procedures would be in place to respond to any emergencies should an accident occur. Additional details are discussed below.

Although the probability of transportation accidents involving hazardous chemicals such as HF and NH_3 is very low, the consequences could be severe. For this EIS, the assessment of transportation accidents involving HF and NH_3 assumed conservative conditions. Currently, a number of industry practices are commonly employed to minimize the potential for large releases, as discussed below.

HF is usually shipped in 100-ton (91-t), 23,000-gal (87,000-L) shell, full, noncoiled, noninsulated tank cars. Most HF railcars today meet DOT Classification 112S500W, which represents the current state of the art. To minimize the potential for accidental releases, these railcars have head protection and employ shelf couplers, which help prevent punctures during an accident. The use of these improved tank cars has led to an improved safety record with respect to HF accidents over the last several years. In fact, the HF transportation accident rate has steadily decreased since 1985. Industry recommendations for the new tank car guideline appear in *Recommended Practices for the Hydrogen Fluoride Industry* (Hydrogen Fluoride Industry Practices Institute 1995b).

Accidents involving HF and NH_3 at a conversion facility could have potentially serious consequences. However, a wide variety of good engineering and mitigative practices are available that are related to siting, design, and accident mitigation for HF and NH_3 storage tanks, which might be present at a conversion facility. Many are summarized in the *Guideline for the Bulk Storage of Anhydrous Hydrogen Fluoride* (Hydrogen Fluoride Industry Practices Institute 1995a). There is an advanced set of accident prevention and mitigative measures that is recommended by industry for HF storage tanks, including storage tank siting principles (e.g., evaluating seismic, high wind, and drainage conditions), design recommendations, and tank appurtenances, as well as spill detection, containment, and mitigation. Measures to mitigate the consequences of an accident include HF detection systems, spill containment systems such as dikes, remote storage tank isolation valves, water spray systems, and rapid acid deinventory systems (that rapidly remove acid from a leaking vessel). Details on these mitigative strategies are also provided in the Hydrogen Fluoride Industry Practices Institute (1995a) guidelines.

5.5 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts are those impacts that cannot be mitigated by choices associated with siting and facility design options. They are impacts that would be unavoidable, no matter which options were selected.

The cylinders currently in storage would require continued monitoring and maintenance under all alternatives. These activities would result in the exposure of workers in the vicinity of the cylinders to low levels of radiation. The radiation exposure of workers could be minimized, but some level of exposure would be unavoidable. The radiation doses to workers are estimated to be well within public health standards under all alternatives. Radiation exposures of workers would be monitored at each facility and would be kept ALARA. Cylinder monitoring and maintenance activities would also emit air pollutants, such as vehicle exhaust and dust (PM_{10}), and produce small amounts of sanitary waste and LLW. Concentrations of air emissions during operations are estimated to be within applicable standards and guidelines, and waste generation would not appreciably affect waste management operations.

Under all alternatives, workers would have a potential for accidental on-the-job injuries and fatalities that would be unrelated to radiation or chemical exposures. These would be a consequence of unanticipated events in the work environment, typical of all workplaces. On the basis of statistics in similar industries, it is estimated that less than 1 fatality and on the order of several hundred injuries would occur under the alternatives, including the required transportation among sites associated with the alternatives. The chance of fatalities and injuries occurring would be minimized by conducting all work activities in as safe a manner as possible, in accordance with occupational health and safety rules and regulations. However, the chance of these types of impacts cannot be completely avoided.

Conversion would require the construction of a new facility at the Paducah site. Up to 45 acres (18 ha) of land could be disturbed during construction, with approximately 10 acres (4 ha) required for the facility footprint. Construction of the facility could result in losses of terrestrial and aquatic habitats. Dispersal of wildlife and temporary elimination of habitats would result from land clearing and construction activities involving movement of construction personnel and equipment. The construction of the facility could cause both short-term and long-term disturbances of some biological habitats. Although some destruction would be inevitable during and after construction, these losses could be minimized by careful site selection and construction practices.

5.6 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The major irreversible and irretrievable commitments of natural and man-made resources related to the alternatives analyzed in this EIS are discussed below. A commitment of a resource is considered *irreversible* when the primary or secondary impacts from its use limit the future options for its use. An *irretrievable* commitment refers to the use or consumption of a resource that is neither renewable nor recoverable for later use by future generations.

The decisions to be made in the ROD following the publication of this EIS would commit resources required for implementing the selected alternative. Three major resource categories would be committed irreversibly or irretrievably under the alternatives considered in this EIS: land, materials, and energy.

5.6.1 Land

Land that is currently occupied by cylinder storage or selected for the conversion facility could ultimately be returned to open space if the yards, buildings, roads, and other structures were removed, the areas were cleaned up, and the land was revegetated. Future use of these tracts of land, although beyond the scope of this EIS, could include restoring them for unrestricted use. Therefore, the commitment of this land would not necessarily be irreversible. However, the land used to dispose of any conversion products or construction or D&D wastes would represent an irretrievable commitment, because wastes in belowground disposal areas could not be completely removed, the land could not be restored to its original condition, and the site could not feasibly be used for other purposes following the closure of the disposal facility. All disposal activities associated with the alternatives analyzed in this EIS would take place at DOE or commercial disposal facilities that would be permitted or licensed to accept such wastes.

5.6.2 Materials

The irreversible and irretrievable commitment of material resources for the various EIS alternatives would include construction materials that could not be recovered or recycled, materials rendered radioactive that could not be decontaminated, and materials consumed or reduced to unrecoverable forms of waste. Materials related to construction could include wood, concrete, sand, gravel, steel, aluminum, and other metals (Table 5.6-1). At this time, no unusual construction material requirements have been identified. The construction resources, except for those that could be recovered and recycled with current technology, would be irretrievably lost. None of the identified construction resources is in short supply, and all should be readily available in the local region.

Strategic and critical materials (e.g., Monel and Inconel) would not be required in quantities that would seriously reduce the national or world supply. This material would be used throughout the facilities and would be used in the generation of HF in the conversion process. The autoclaves and conversion units (process reactors) are long-lead-time procurements with few qualified bidders. Many suppliers are available for the remainder of the equipment.

Estimated annual consumption rates of raw materials are provided in Table 5.6-2. Consumption of operating supplies (e.g., miscellaneous chemicals such as lime and potassium hydroxide, and gases such as nitrogen), although irretrievable, would not constitute a permanent drain on local sources or involve any material in critically short supply in the United States as a whole.

TABLE 5.6-1 Materials/Resources Consumed during Conversion Facility Construction at the Paducah Site

Materials/Resources	Total Consumption	Unit	Peak Demand	Unit
Utilities				
Water	4×10^6	gal	1,500	gal/h
Electricity	1,500	MWh	7.2	MWh/d
Solids				
Concrete	9,139	yd^3	NA[a]	NA
Steel	511	tons	NA	NA
Inconel/Monel	33	tons	NA	NA
Liquids				
Fuel	73,000	gal	250	gal/d
Gases				
Industrial gases (propane)	15,000	gal	50	gal/d

[a] NA = not applicable.

5.6.3 Energy

The irretrievable commitment of energy resources during the operation of the various facilities considered under the alternatives would include the consumption of fossil fuels used to generate steam and heat and electricity for the facilities (Table 5.6-3). Energy would also be expended in the form of diesel fuel and gasoline for cylinder transport equipment and transportation vehicles. Consumption of these utilities, although irretrievable, would not constitute a permanent drain on local sources or involve any utility in critically short supply in the United States as a whole.

TABLE 5.6-2 Materials Consumed Annually during Conversion Facility Operations at the Paducah Site[a]

Chemical	Quantity (tons/yr)
Solid	
Lime (CaO)[b]	19
Liquid	
Ammonia (99.95% minimum NH_3)	670
Potassium hydroxide (45% KOH)	8
Gas	
Nitrogen (N_2)	10,000

[a] Material estimates are based on conceptual-design-status data (UDS 2003b). A number of studies are planned to evaluate design alternatives, the results of which may affect the above materials needs.

[b] Assuming lime is used only for potassium hydroxide regeneration. If HF neutralization is required, the annual lime requirement would be approximately 9,300 tons/yr (8,437 t/yr).

TABLE 5.6-3 Utilities Consumed during Conversion Facility Operations at the Paducah Site[a]

Utility	Annual Average Consumption	Unit	Peak Demand[b]	Unit
Electricity	37,269	MWh	7.1	MW
Liquid fuel	4,000	gal	NA[c]	NA
Natural gas[d,e]	4.4×10^7	scf[f]	190	scfm[f]
Process water	37×10^6	gal	215	gal/min
Potable water	3×10^6	gal	350	gal/min

[a] Utility estimates are based on conceptual design status data (UDS 2003b). A number of studies are planned to evaluate design alternatives, the results of which may affect the above utility needs.

[b] Peak demand is the maximum rate expected during any hour.

[c] NA = not applicable.

[d] Standard cubic feet measured at 14.7 psia and 60°F (16°C).

[e] The current facility design (UDS 2003b) uses electrical heating. An option of using natural gas is being evaluated.

[f] scf = standard cubic feet; scfm = standard cubic feet per minute.

5.7 RELATIONSHIP BETWEEN SHORT-TERM USE OF THE ENVIRONMENT AND LONG-TERM PRODUCTIVITY

For this EIS, *short term* is considered the period of construction activities for the alternatives analyzed — the time when most short-term (or temporary) environmental impacts would occur. Disposal of solid nonhazardous waste resulting from new facility construction, operations, and D&D would require additional land at a sanitary landfill site, which would be unavailable for other uses in the long term. Any radioactive or hazardous waste generated by the various alternatives would involve the commitment of associated land, transportation, and disposal resources, and resources associated with the processing facilities for waste management.

For the construction and operation of the conversion facility, the associated construction activities would result in both short- and long-term losses of terrestrial and aquatic habitats from natural productivity. Dispersal of wildlife and temporary elimination of habitats would result from land clearing and construction activities involving movement and staging of construction personnel and equipment. The building of new facilities could cause long-term disturbances of some biological habitats, potentially causing long-term reductions in the biological activity of an area. Although some habitat loss would be inevitable during and after construction, these losses would be minimized by careful site selection and by thorough environmental reviews of specific proposals. Short-term impacts would be reduced and mitigated as necessary. After closure of the new facilities, they would be decommissioned and could be reused, recycled, or remediated.

5.8 POLLUTION PREVENTION AND WASTE MINIMIZATION

Implementation of the EIS alternatives would be conducted in accordance with all applicable pollution prevention and waste minimization guidelines. Pollution prevention is designed to reduce risk to public health, safety, welfare, and the environment through source reduction techniques and environmentally acceptable recycling processes. The Pollution Prevention Act of 1990 (42 USC 11001–11050) established a national policy that pollution should be prevented or reduced at the source, whenever feasible. The act indicates that when pollution cannot be prevented, polluted products should be recycled in an environmentally safe manner. Disposal or other releases into the environment should be employed only as a last resort. Executive Order 12856, *Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements* (U.S. President 1993), and DOE Order 5400.1, *General Environmental Protection Program* (DOE 1988), implement the provisions of the Pollution Prevention Act of 1990. Pollution prevention measures could include source reduction, recycling, treatment, and disposal. The emphasis would be on source reduction and recycling to prevent the creation of wastes (i.e., waste minimization).

Waste minimization is the reduction, to the extent feasible, of the generation of radioactive and hazardous waste. Source reduction and waste minimization techniques include good operating practices, technology modifications, changes in input material, and product changes. An example of waste minimization would be to substitute nonhazardous materials, when possible, for materials that contribute to the generation of hazardous or mixed waste.

A consideration of opportunities for reducing waste generation at the source, as well as for recycling and reusing material, will be incorporated to the extent possible into the engineering and design process for the conversion facility. Pollution prevention and waste minimization will be major factors in determining the final design of any facility to be constructed. Specific pollution prevention and waste minimization measures will be considered in designing and operating the final conversion facility.

5.9 DECONTAMINATION AND DECOMMISSIONING OF THE CONVERSION FACILITY

When operations at the conversion facility are complete, D&D would be performed to protect both public health and safety and the environment from accidental releases of any remaining radioactivity and hazardous materials. The conversion facility is being designed to facilitate D&D activities. This analysis assumes that the D&D activity would provide for the disassembly and removal of all radioactive and hazardous components, equipment, and structures associated with the conversion facilities. The objective assumed in this EIS would be to completely dismantle the various buildings and achieve “greenfield” (unrestricted use) conditions. The design requirements for the D&D of these facilities can be found in two DOE Directives from 1999: DOE Guide 430.1-3, *Deactivation Implementation Guide*, and DOE Guide 430.1-4, *Decommissioning Implementation Guide* (DOE 1999e,f).

Because the D&D of the proposed facility is not expected to occur for at least 25 years, it is likely that an additional environmental review would need to be performed before it occurred. It is also expected that such a review would be based on the actual condition of the facilities and a more definite identification of the resulting waste materials.

5.9.1 Human Health and Safety — Off-Site Public

It is expected that D&D of the DUF_6 conversion facility would result in low radiation doses to members of the public and would be accomplished with no significant adverse environmental impacts.

DOE has established a primary dose limit for any member of the public of 0.1 rem (1 mSv) total effective dose equivalent (TEDE) per year for protection of public health and safety. Compliance with the limit is based not just on an individual DOE source or practice but on the sum of internal and external doses resulting from all modes of exposure to all radiation sources other than background and medical sources (DOE 1993). However, it could be very difficult to determine doses from all radiation sources for the purpose of demonstrating compliance. Therefore, DOE elements are instructed to apply a public dose constraint of 0.025 rem (0.25 mSv) of TEDE per year to each DOE source or practice (DOE 2002g). Also, DOE elements are required to implement a process to ensure, on a case-specific basis, that public radiation exposures will be ALARA below the dose constraint (DOE 1993).

To be consistent with DOE's general approach to protecting the public from radiation exposure explained above, the release of radioactive material from D&D activities at a DOE-controlled site, such as a DUF_6 conversion or cylinder treatment facility, would be limited to an amount determined on a case-specific basis through the ALARA process to be ALARA but, in any event, less than 0.025 rem/yr (0.25 mSv/yr). This would ensure that doses to the public from DOE real property releases following D&D are consistent with NRC requirements for commercial nuclear facilities, as stated in 10 CFR 20, Subpart E, "Radiological Criteria for License Termination."

In its final generic EIS for decommissioning of NRC-licensed nuclear facilities (NRC 1994), the NRC concluded that at any site where the 0.025-rem/yr (0.25-mSv/yr) dose criterion established in 10 CFR 20, Subpart E is met, the likelihood that individuals who use the site would be exposed to multiple sources with cumulative doses approaching 0.1 rem/yr (1 mSv/yr) would be very low. Accordingly, the likelihood would also be very low that a member of the public would be exposed in excess of the DOE primary dose limit after D&D of the DUF_6 conversion and cylinder treatment facilities to meet site-specific limits that are ALARA below the dose constraint of 0.025 mrem/yr (0.25 mSv/yr).

The total public dose from D&D of the DUF_6 conversion facility is estimated to range from 4 to 5 person-rem. This estimate was scaled from data on public exposure doses found in NRC (1988) to account for the capacity of the conversion facility and the effort required for its D&D. Because of the low specific activity of uranium, the estimate is very small and primarily would result from the transportation of D&D wastes for ultimate disposition (NRC 1988).

Radiation doses to the public resulting from accidents during D&D activities would be low enough to be considered insignificant (NRC 1988).

5.9.2 Human Health and Safety — On-Site Workforce

Radiological impacts to involved workers during D&D of the conversion facility would result primarily from external radiation due to the handling of depleted uranium materials. Because of the low radiation exposures from depleted uranium, one of the initial D&D activities would be removal of any residual uranium from the process equipment, significantly reducing radiation exposure to the involved workforce.

Radiation exposure estimates for the involved workforce during D&D activities involving nuclear facilities licensed by the NRC are provided in NRC (1988) and NRC (1994). These nuclear facilities include UF_6 production plants and uranium fuel fabrication plants that are similar to the conversion facilities considered in this EIS. Average radiation dose rates in the conversion facility during the initial cleaning are expected to be much less than 2 mrem/h, which is the radiation dose rate from bulk quantities of uranium (NRC 1988).

Table 5.9-1 lists the estimated LCFs of the involved workforce during decontamination and cleanup activities at the facility as a function of the residual dose rate (NRC 1994). The radiological impacts in Table 5.9-1 were estimated on the basis of the dose rates to which the workers are subjected and the collective effort required to reduce the residual contamination levels.

One of the most critical parameters in developing the decommissioning plan would be the release criterion applicable for the project. Subpart E of 10 CFR Part 20 addresses release criteria for NRC licensees, while DOE Order 5400.5 (DOE 1990) governs the development of authorized release limits for DOE facilities. On the basis of a residual dose rate of 25 mrem/yr, the estimated LCFs of the involved workforce would be much lower than unity (i.e., no radiation-related fatalities), since the radiation dose to involved workers would be a small fraction of the exposure experienced over the operating lifetime of the facility and well within the occupational exposure limits imposed

TABLE 5.9-1 Estimated Latent Cancer Fatalities from Radiation Exposure Resulting from Conversion Facility D&D Activities at the Paducah Site[a]

Residual Dose Rate (mrem/yr)	Low[b]	High[c]
100	2.12×10^{-3}	3.61×10^{-3}
60	2.12×10^{-3}	3.63×10^{-3}
30	2.12×10^{-3}	3.65×10^{-3}
15	2.14×10^{-3}	3.66×10^{-3}
10	2.16×10^{-3}	3.67×10^{-3}
3	2.18×10^{-3}	3.68×10^{-3}
1	2.19×10^{-3}	3.69×10^{-3}
0.3	2.19×10^{-3}	3.70×10^{-3}
0.1	2.20×10^{-3}	3.71×10^{-3}
0.03	2.20×10^{-3}	3.72×10^{-3}

[a] Values in this table are unscaled values taken directly from NRC (1994).

[b] Based on the D&D of a uranium fuel fabrication plant that converts enriched UF_6 into UO_2 for production of light-water reactor fuel (DOE 1999g).

[c] Based on the D&D of a UF_6 production plant where yellowcake is converted to UF_6.

by regulatory requirements. Radiation exposure of the involved D&D workers would be monitored by a dosimetry program and maintained below regulatory limits.

The risk of on-the-job fatalities and injuries to conversion facility D&D workers was calculated by using industry-specific statistics from the BLS, as reported by the National Safety Council (2002). Annual fatality and injury rates from the BLS construction industry division were used for the D&D phase. On the basis of D&D cost information provided in Elayat et al. (1997), it is assumed that the D&D workforce would be approximately 10% of the construction workforce. On the basis of these assumptions and information provided in UDS (2003b), the estimated incidences of fatalities and injuries for the D&D of the conversion facilities are 0.01 and 5, respectively.

5.9.3 Air Quality

Before structural dismantlement, all contaminated surfaces would be cleaned manually. Best construction management practices, such as dust control measures, would be used to protect air quality and to mitigate any airborne releases during the D&D process. As discussed in Section 5.9.1, it is anticipated that the D&D activities would not produce any significant radiological emissions that would affect the off-site public.

D&D can be considered to be the reverse of the construction of buildings and structures. Available information (Elayat et al. 1997) indicates that the level of construction-related activities during D&D would be an order of magnitude lower than during conversion facility construction. Air quality during D&D activities would thus be bounded by the results presented in Sections 5.2.1.3 and 5.2.2.3 for construction activities, if it is assumed that the existing emission control systems were efficiently maintained.

5.9.4 Socioeconomics

The potential consequences from D&D of the conversion facilities would be lower than those discussed in Section 5.2.1.5 for conversion facility construction, because the total D&D workforce would be smaller for facility D&D than for facility construction.

To decommission the conversion facility, many of the same people who operated the facility could do the cleaning; however, the dismantling and moving of equipment would have to be performed by electricians, plumbers, mechanics, and equipment operators, most of whom would be hired or contracted (NRC 1988) specifically for this purpose.

5.9.5 Waste Management

The major challenge of the D&D activity would be to remove and dispose of radioactive and hazardous wastes while keeping occupational and other exposures ALARA. Section 3.7 of DOE Guide 420.1-1 (DOE 2000c) requires facilities where radioactive or other hazardous contaminating materials will be used to be designed so as to simplify periodic decontamination and ultimate decommissioning. For example, if necessary, all cracks, crevices, and joints would have to be caulked or sealed and finished smooth to prevent the accumulation of contaminated material in inaccessible areas. These design features should minimize the generation of radioactive and/or hazardous materials during D&D activities.

There are three major classes of D&D waste, based on the composition and radioactivity of the materials involved: LLW, mixed LLW, and hazardous waste. It is assumed that TRU waste would not be present (any TRU waste generated during facility operations would be removed prior to D&D activities). A fourth class is "clean" material; this is any material resulting from D&D activities, including metal, which can be safely reused or recycled without any further radiological or hazardous controls. If no further need is established for these clean materials, they can be disposed of at sanitary landfills without requiring any further radiological or hazardous controls.

D&D-related waste can also be categorized into two general groups: contaminated materials and other wastes. Contaminated materials are standard materials such as steel and concrete that contain or have embedded trace amounts of radioactivity. In general, contamination is caused by the settling or adherence of uranium and its progeny products on internal surfaces such as piping. The average concentrations of the radionuclides contaminating the conversion facility are expected to be generally low enough to rank these materials as Class-A LLW.

Other wastes, the second general group of D&D-related wastes, are composed of materials that can become radioactively contaminated when plant workers use them. They include gloves, rags, tools, plastic sheeting, and chemical decontaminants. These wastes are also expected to have an average radioactivity low enough to be ranked as Class-A LLW. This analysis assumes that the quantities of other wastes would be much lower than those generated during facility deconstruction.

It is assumed that the soil within the conversion facility perimeters would not be contaminated with radiological or hazardous materials as a result of normal facility operations and therefore would not require excavation and subsequent treatment and disposition. If soil was contaminated due to an accidental release, it would be cleaned up as quickly as possible after the release occurred and would not be part of the D&D wastes.

The methodology outlined in Forward et al. (1994) was used to estimate the volumes and types of wastes that would be generated from the D&D of the conversion facility. Because contaminant inventories for these facilities are unavailable, reference data on the contaminant inventory data compiled by the NRC were applied. Facilities are categorized in Forward et al. (1994) into different types on the basis of their function, structure, design, and degree of D&D difficulty. This analysis assumes that the conversion facilities could be considered to be "radioactively contaminated buildings" with a "low" degree of D&D difficulty.

On the basis of the above assumptions and information provided in UDS (2003a), the annual and total waste generation rates from the D&D of the conversion facility were estimated and are provided in Table 5.9-2. Of the total materials generated during the D&D of the conversion facility, both LLMW and hazardous wastes would make up 2% to 3% of the total, and LLW would constitute about 6% to 7%. The majority of the D&D materials (approximately 88% of the total) would be “clean.”

The “clean” waste would be sent to a landfill that accepts construction debris. LLW would be sent to a licensed disposal facility where it would likely be buried in accordance with the waste acceptance criteria and other requirements in effect at that time. Hazardous and mixed waste would be disposed of in a licensed facility in accordance with applicable regulatory requirements.

TABLE 5.9-2 Annual and Total Waste Volume Estimates from Conversion Facility D&D Activities at the Paducah Site

Waste Type	Annual D&D Waste (m^3/yr)[a]	Total D&D Waste (m^3)
LLMW	40	110
Hazardous waste	40	110
LLW	70	200
Clean	1,200	4,000

[a] Annual rates based on 3-year D&D.